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STRIPPING SWEET CLOVER PLANTS OF THEIR SEED.—[See page 109]

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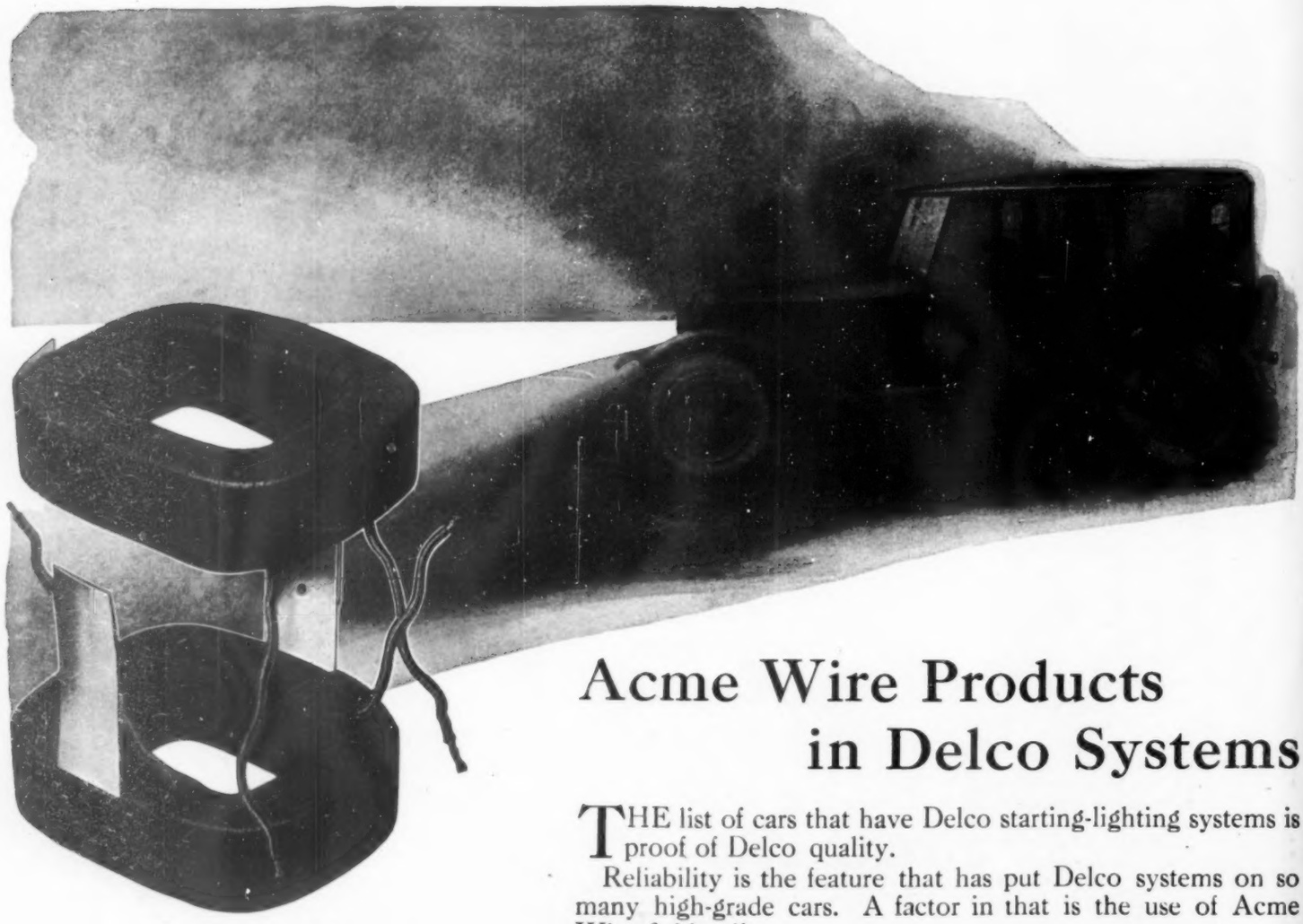

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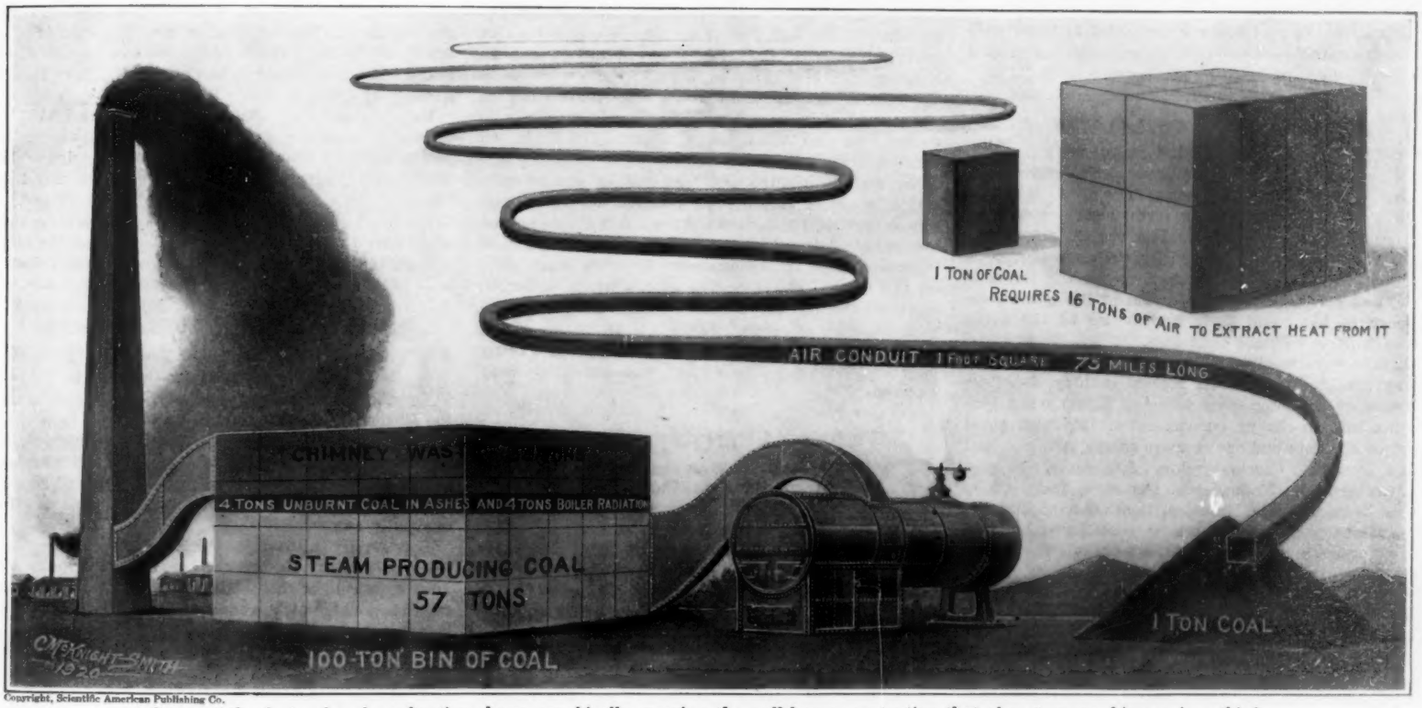

Some of the facts of coal combustion shown graphically, proving the well-known contention that almost every chimney is a thief

Stopping the Chimney Thief

By Charles C. Phelps

EVERY chimney on every power plant is by nature a thief. Give them a chance and they will rob you of fuel. Many have been broken of their heat-pilfering ways by the hand of science but a much greater number of them still stand as monuments to the American spirit of wastefulness.

Of two exactly similar chimneys standing side by side, the most skilled observer could not tell by merely looking at them which one was guilty and which one innocent of robbing its owner of heat and of depriving the nation forever of just so much of its most precious natural resource—fuel. Everybody knows that smoke means unconsumed fuel and still a chimney belching forth dense black smoke is very likely to be less of a waster than its innocent appearing smokeless twin. In spite of the popular impression to the contrary, smoke, nuisance though it is on its own grounds, seldom represents a loss greater than one per cent of the fuel.

Heat escaping up the chimney represents by far the biggest fuel loss. The remaining losses of fuel, principally due to radiation from the boiler and furnace covering and to fuel actually escaping before it has been completely burned, are insignificant in comparison to the chimney loss in the great majority of plants.

"In the average boiler plant, 35 per cent of the heat in the coal burned under the boilers is lost with the stack gases. That is, out of every 100 tons of coal burned under the boilers, the heat of 35 tons literally goes up the stack. It is this loss that can be greatly reduced and every effort should be made to do so. The stack loss is so large because its magnitude cannot be readily detected, but can be found only by the use of special instruments and carefully kept records." (*U. S. Bureau of Mines, Technical Paper No. 265.*)

Although the above statement refers specifically to coal, similar losses occur when other fuels, such as oil, gas, coke and wood, are burned, and in many plants much more than 35 per cent of the heat escapes up the chimney, that figure representing only average conditions. Most of this 35 per cent waste is absolutely unnecessary and in plants where the furnaces are operated in accordance with correct principles, this 35 per cent of the fuel is in fact largely utilized in evaporating water into steam, instead of warming up all outdoors. Some of the most efficient power plants actually waste as little as 10 or 12 per cent of their fuel up the chimney. This is about as good a result as it is humanly possible to accomplish in the present state of the engineering art.

The greater part of the 35 per cent chimney loss is due to using too much air in burning the fuel. We have a somewhat similar example in the case of the old-fashioned grate fireplace. It is cheery and picturesque but the coal consumed in a grate fire to heat one room would often be more than enough to heat an entire house if it were burned in a modern steam or hot-water heater. One reason the grate fire is such a waster is because most of the heat in the fuel is utilized in heating air drawn into the chimney by the draft. The heated gases from the fire mix with air and this mixture of hot gas and hot air shoots right up into the chimney before it has an opportunity to give up much of its heat. As the hot gases and air ascend the chimney in great volume more air must be drawn into the room continually to take the place of that escaping with the hot products of combustion. Cold air necessarily must leak in around the windows, doors, and through various crevices and it then becomes a question whether the heating effect of the fire or the refrigerating effect of the air-leaks will win out.

In burning fuel in a boiler furnace, the same principle is involved. If too strong a draft is employed for the amount of fuel that is being consumed, more air will enter the furnace than is needed for the process of combustion and the excess air will simply mix with the hot gases and lower their temperature. The excess air will, so to speak, soak up a lot of the heat units that ought to be absorbed by the boiler and will carry them rapidly out of the furnace and up the chimney. Excessive draft also means excessive velocity of hot gases passing over the boiler surfaces and therefore insufficient time to give up heat to the boiler before leaving it.

Before explaining how combustion is controlled with the aid of instruments it would be well to outline the elements of the chemistry of combustion. The principal constituent of most fuels is carbon. Hydrogen is also an important component of many fuels. In the process of combustion, both of these elements unite with the oxygen in the air which comes in contact with the fuel and it is this chemical combining of oxygen with carbon and with hydrogen that produces the intense heat in the furnace. Other combustible substances are also present but they are usually in such small proportions that they do not contribute very much heat and can therefore be left out of consideration here.

The carbon should all burn up to carbon dioxide gas, and the hydrogen to water vapor. These *gaseous* waste products are often given scant consideration, yet they may aggregate in weight several hundred times as much as the *solid* waste products—the ashes. So, if it pays the frugal housewife to sift her ashes with care, how much more profitable must it be for the power plant owner to insist that all of the gases escaping from his furnaces be examined for heat losses?

Combustion being a chemical process, it follows that

(*Continued on page 115*)

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The object of this journal is to record accurately and lucidly the latest scientific, mechanical and industrial news of the day. As a weekly journal, it is in a position to announce interesting developments before they are published elsewhere.

The Editor is glad to have submitted to him timely articles suitable for these columns, especially when such articles are accompanied by photographs.

How the Einstein Contest Worked

THE interest taken in the contest from the first, alike on the part of prospective contestants and of those who expected only to read the essays which it would bring forth, has been all that we could have anticipated. The contest must have been very handsomely treated by our contemporaries, for we have received many requests for full information, and a considerable proportion of the contestants appear to have had their first notice of the event through other columns than ours.

Essays were received in greater quantity from Germany than from any other foreign country, doubtless because of the staggering value of $5,000 when converted into marks at current rates. England stood next on the list; and one or more essays were received from Austria, Czechoslovakia, Jugoslavia, France, Switzerland, the Netherlands, Denmark, Italy, Chile, Cuba, Mexico, India, Jamaica, South Africa and the Fiji Islands. Canada, of course, contributed her fair share; and few of our own states were missing on the roll-call.

The general level of English composition among the essays from non-English-speaking sources was about what might have been expected. A man may have a thorough utilitarian knowledge of a foreign tongue, but when he attempts intensive literary competition with a man who was brought up in that tongue he is at a disadvantage. We read French and German with ease and Spanish and Italian without too much difficulty, ourselves; we should never undertake serious writing in any of these languages. Not many of the foreign contributions, of course, were as ludicrous as the one we quoted on this page on November 6th; but most of them were distinctly below par as literary compositions. De Sitter and Schlick, mentioned on another page, were the notable exceptions to this; both showed the ability to compete on a footing of absolute equality with the best of the native product. Dr. Schlick's masterly handling of the language it was that got honorable mention in the editorial of November 6th.

A very material proportion of the essays was eliminated on the ground that the authors had not properly carried out the terms of the contest calling for intelligibility to the general reader. As we indicated last week this is of course partly a matter of definition; and of course it is the Judges' definition that must prevail. But it was rather a matter of surprise, on opening the identifying envelopes, to discover the distinguished identities of some of the men who had written with complete misconception of the character of the audience. Our horrible examples of last week should make this sufficiently clear.

We dare say it was a foregone conclusion that many essays should be over the limit, and that a few should be over it to the point of absurdity. The winning essay contains 2,919 words, plus or minus a reasonable allowance for error in counting; that it should come so far from being on the ragged edge should be sufficient answer to those who protested against the severity of the limitation. One inquirer, by the way, wanted to know if 3,000 words was not a misprint for 30,000. Another contestant suggested that instead of disqualifying any essay that was over the line, we amputate the superfluous words at the end. This was a plausible enough suggestion, since any essay able to compete after such amputation must necessarily have been one of extreme worth; but fortunately we did not have to decide whether we should follow the scheme. Perhaps twenty of the essays submitted were so seriously in excess of the limit that it was not even necessary to count their words in detail; most of these offenders ran to 3,500 words or thereabouts, and one of them actually had 4,700. On the other extreme were a few competitors who seemed to think that the shortest essay was necessarily the best, and who tried to dismiss the subject with 500 or 1,000 words.

The first essay received wandered into our office in the middle of September—and it was a good one, too. The great avalanche, however, was reserved for the morning of Monday, November 1st. We had been in consultation with the Judges on Saturday, and so had the benefit of three day's mail; there were about 120 essays. Among those which were thrown out on the ground of lateness the honors should no doubt go to the man who mailed his offering in The Hague on October 31st.

We had anticipated that the bulk of the superior essays would be among those received during the last day or two of the contest; for we felt that the men best equipped to attack the subject would be the most impressed with its seriousness. Here we were quite off the track. The seventeen essays which withstood most stubbornly the Judges' efforts at elimination were, in order of receipt, numbers 8, 18, 28, 40, 41, 43, 92, 95, 97, 130, 181, 194, 198, 223, 267, 270, 275, a fairly even distribution. The winner was the 92nd essay received.

Pushing a Good Principle Too Far

THE action of the War Department in demanding that several of the long piers of the Hudson River be shortened will render it necessary for our largest transatlantic liners to dock elsewhere than at Manhattan Island. Several years ago, when the first of the super-liners (if we may use that term), the ill-fated "Lusitania," was nearing completion and other still larger ships were contemplated, there was an agitation for an increase in the length of certain piers in the North River to a maximum length of about 1,000 feet. After a very thorough discussion of the pros and cons of this matter, the War Department gave permission for the temporary lengthening of a stretch of piers in the Chelsea District by the addition of 100 feet more or less to their existing length. This renders it possible for such ships as the "Olympic," the "Aquitania," the "Imperator" and the "Leviathan" to berth at these piers with the whole of their length, (in the case of the "Leviathan," 950 feet,) within the shelter of the pier and clear of the North River fairway. The period of years for which this permit for lengthening was granted has now expired, and the companies affected have received a peremptory order to remove the 100-foot extension. The object of the removal is to prevent any interference with the "tidal velocity" in the North River. The companies affected are the International Mercantile Marine and the Cunard Line, the former an American concern, over 95 per cent of whose stock is owned in America, and the latter a British company; and these two between them own the largest ships that are engaged in the transatlantic trade.

Now it seems to us that this action of the War Department is a case of pushing a good principle a little too far. It is eminently desirable, of course, that the Federal Government should exercise a jealous oversight of all great national facilities, prominent among which are our rivers and harbors. The immediate supervision of bulkhead lines and bridge clearances is under the care of the corps of Army engineers, a most able body of men who have fulfilled this part of their duties with conscientious care and on the whole with wise discrimination. Thanks to them, our waterway facilities, in the case both of our rivers and harbors, have been preserved from private exploitation. No bridge can be thrown across a navigable stream without their permission, nor can any pier be advanced into a navigable waterway or harbor beyond the bulkhead lines which they have laid down. Having admitted all this, we feel today, as we have for many years past, that in the matter of encroachments upon the width of the North River at the port of New York, the Army engineers are allowing their zeal to throw their vision out of focus. The question of the advancement of bulkhead lines into a navigable river is one of a nice adjustment between the convenience of shipping passing up and down the river and shipping that is moored to the piers. The minimum width between pierhead lines on opposite shores of the North River at present is about 3,000 feet, or over three times the length of the largest liners that use this port. We fail to see how a plus or minus of 100 feet in a width of 3,000 is going to make any appreciable difference in the velocity of the river current. Experienced river pilots affirm that the 100-foot extension has made no difference in the tidal velocity, or if it has, that it is so small as to be indistinguishable—and surely these pilots, of all men, ought to be the best judges of the behaviour of ships in North River docking.

More serious than the question of current velocity is that of room for maneuvering into and out of the pier basins and interference with passing ships. This is not serious at present, nor can we foresee any time when it will be. Compared with other great ports—Liverpool, London, Hamburg—New York has thousands of feet width to their hundreds. To shorten the piers and curtail the size of ships in favor of the fairway is to sacrifice the greater for the lesser problem.

Monumental Bridge To Be Preserved

THE Board of Estimate of New York City should be congratulated upon its decision to remodel the historic and beautiful High Bridge across the Harlem in accordance with the suggestions of those citizens who wish to see the inherent beauty of the structure preserved. This is to be done by spanning the river with a single stone arch instead of making the crossing with a straight steel span, as was originally suggested.

The rigidly utilitarian spirit which for so many years controlled the growth of this metropolis has been softened, in these later days, by a growing appreciation of the claims which considerations of beauty, harmony and dignity should receive in the planning of city improvements and the design of its monumental structures. There can be no denying that for the lack of this appreciation, New York City has suffered greatly in the years gone by. Historical landmarks which were closely interwoven with the history, not merely of the city, but of the nation itself, have been either ruthlessly swept aside or suffered to fall into irretrievable decay.

The justly celebrated High Bridge came very near to being a case in point. Happily, the demand of the War Department for the removal of certain piers which obstruct navigation in the Harlem River will now be met in a way which certainly will not spoil the appearance of the famous aqueduct, and may well, indeed, be found to grace it with added beauty. The placing of one large arch in the center of the long succession of uniform arches which make up the bridge will introduce a pleasing variety; and in spanning the river in one great sweep, the arch will commend itself to the engineer and the architect as an appropriate solution of the problem. The more so, since the cut stone from the dismantled piers in the river will provide sufficient facing material for the big arch, and will secure the happy result that it will harmonize, not merely in form but in coloring, with the rest of the structure.

Historically, the High Bridge aqueduct will always be of interest, since it forms an important link in the first attempt to provide New York with a water supply adequate to its existing needs and capable of meeting the increasing demands of the future. The Croton dam, the aqueduct and the receiving and distributing basins in Central Park and at Forty-Second Street and Fifth Avenue were all built in the early forties. They have now been outbuilt by the great Catskill reservoirs and aqueduct. High Bridge, however, will remain as a concrete example of the fine work done by the engineers of that early period.

Engineering

The Power of a Cloudburst is vividly demonstrated in the recent experience of Toledo, Ohio. Block paving on a cement sand cushion was washed away during heavy rainstorms. The blocks are being replaced on an asbestos binder course, which provides a much better bottom seal against water. Chicago is also experimenting with asphalt-sand cushions.

California's Water Supply Problems. — Owing to scant rainfall in California, numerous schemes are proposed to provide water for towns and irrigation. Several of these schemes involve large expenditures and all require the movement of water over long distances. In two cases it is proposed to divert rivers completely.

Rapid Filtration. — Sir A. C. Houston's thirteenth research report to the Metropolitan Water Board is sharply criticised from the water-engineer's point of view, largely on the ground that slow sand filter beds in practical use are compared as to their working with a minute laboratory experimental filter, consisting of a glass tube of about 18 inches in length and ¾ inch in diameter, in a recent issue of the *Surveyor*.

Steel Tires Imbedded in Concrete. — In order to save head-space a railroad has built bridges at Indianapolis in which the spaces between the cross I-beams are filled with reinforced concrete. This gives a waterproof floor with minimum thickness. The rails are carried on steel sleepers set in the concrete, and are fastened to the sleepers by dogs which can be removed without disturbing the floor.

Rammed-Earth Construction. — Architects are suggesting that the high cost of house building in America be reduced by the use of a compressed earth. Clayey and somewhat sandy loam is mixed with straw or hay to prevent cracking. The wall is built in sections by means of a movable frame into which the moist earth is rammed or beaten in 4-inch layers. The outer surface of this so-called wall can be colorwashed or treated in various ways.

Road Building in Shantung. — In connection with famine relief measures in Shantung, surveys are being made for the construction of a dirt road from Tungchangfu and Wuting, two important centers in the Province. The proposal would appropriate the sum of $300,000 (local currency). The road will penetrate one of the worst famine districts of Shantung and afford direct connection with the main railway line from Tientsin south of the Yangtze River.

Concrete Beam Tests.—These tests were conducted by the U. S. Reclamation Service at North Platte, Wyoming, under conditions simulating field work, and were made to determine the advisability of using a local gravel as an aggregate. Some of the resultant conclusions are of more or less general application, and these may be shortly summarized as follows: (1) The strength of beams covered with sand during curing showed an increase over those not so covered of from 40 to 55 per cent.; (2) 1 : 2½ : 5 beams covered while curing for both 30 and 90 days tests were stronger than 1 : 2 : 4 beams of the same age that were not covered while curing; (3) where concrete dries out too quickly there is a marked decrease of strength.

Corrosion of Railroad Tie Plates. — A series of tests have been made by the New York Central Lines with the idea of finding the magnitude of the corrosion on tie plates, and the best method of reducing its amount. The test plates were inserted either in the track or in exposed positions, and the results show that corrosion occurs mainly on the under surface, the amount of corrosion being measured by the percentage loss of weight during the test. Tests have been made on special steel, Bessemer steel, high carbon Bessemer steel, open-hearth steel, pure iron and malleable iron, such tests taking from 2 to 6 years, and it is shown that the corrosion is a minimum with a steel containing 0.25 per cent copper.

Steel Replacing Wood for Concrete Formwork.— Until two or three years ago formwork has lagged in its development in comparison with other factors in the use of reinforced concrete, states *Technical Review*. The increasing cost of timber, however, is bringing about a revolution in formwork. Steel forms have been used, indeed, for some years in the construction of concrete pipes, tunnels, sewers, and curbs; but they are particularly successful in column work, and have been in use since 1911 for floor work. They are now being introduced in flat slab construction. The chief problem yet to be solved is their application to the construction of concrete beams and girders, after which entire concrete buildings can be constructed from steel forms "with, at least, 95 per cent salvage."

Science

The Federal Government has purchased the Quarantine Station at New York from the State of New York. This includes Hoffman and Swinburne Islands in the outer harbor with their buildings and equipment including the boats. It is desirable to have this great gateway of the Nation under Federal control.

The American Metric Association recently held its fourth annual meeting and discussed the means of introducing the system into the United States. A bill is now before Congress to establish it as a single standard, after a transitional period of ten years. Even the war does not seem to have made any material advance in the use of the metric system. Our present system was described by Professor Kennelly as "the curse of Babylon, the old man of the sea, whose tail is around our necks."

The Alpine Club and Royal Geographical Society are making plans to climb Mount Everest, 29,002 feet above sea level and consequently the highest mountain in the world. All approaches even to the foot hills are practically unknown. Mount Everest is guarded not only by Nature but by man for it lies on the frontier of Nepal and Tibet—two lands virtually closed to the explorer. Fortunately permission has been granted by the Dalai Lama at Lhasa so that the difficulties are now merely those of the mountaineer. The hardships cannot be overestimated and the best experts of the world will be consulted. At least two years will be consumed before there is any likelihood of success. No peak of over 24,000 feet has been ascended, so that it is not known how the explorers will stand the endurance test.

A Depot-Laying Expedition in the Arctic, carried out by Capt. G. Hansen by order of the Norwegian Government for the benefit of Capt. Amundsen, is reported in the London *Times* to have completed its work safely. After wintering at the Eskimo settlement of Thule, in Greenland, Hansen started north in March, 1920, accompanied by several Eskimos who had formerly served under Peary. The party followed the coast of Greenland to the north of Franklin Island and then crossed Kennedy Channel on the ice to Grinnell Land. Cape Sheridan was rounded with difficulty, on account of extremely rough pack, and the goal of the expedition was reached at Cape Columbia, Grant Land. The series of depots laid to that point will enable Amundsen, if his drift brings him near Cape Columbia, to travel thence by easy stages to the Danish settlements in Greenland.

The "Bicentenary" Expedition to North Greenland.—Under this title Lauge Koch, the Danish explorer, sets forts in the *Geographical Review* his plans for a geographical and geological expedition to North Greenland during the year 1921, which is the 200th anniversary of Hans Egede's departure from Copenhagen as a missionary to Greenland; the first step in the systematic colonization of Danish possessions in the Arctic. Lauge points out that the whole coast-line of Greenland is now known, and that the coast of Peary Land, the most inaccessible part of Greenland, has been reached from both sides. The interior of Peary Land, however, is absolutely unknown. The new expedition is already in the field, having sailed from Copenhagen July 15, 1920, for Robertson Bay, in Inglefield Gulf, where it was to winter. Koch is accompanied by a Danish engineer, C. F. Slott, who is an expert in the use of tractors, which are used in carrying provisions across the inland ice.

Geothermal Data of the United States.—U. S. Geological Survey Bulletin 701, by N. H. Darton, is a collection, by states, of all available data of subterranean temperatures in this country. Several hundred of the observations recorded in this bulletin were taken by the author and his associates with the Darton self-registering maximum thermometer, which is a slight modification of that used by William Hallock. The geological relations of the wells in each state are discussed. In most wells that penetrate sedimentary rocks not greatly disturbed there seems to be no distinct relation between the formation penetrated and the geothermal gradient. A striking exception is the Des Moines well, in Iowa, which shows a sudden change from a rate of increase of 1 degree in 75 feet above the Devonian to 1 degree in 272 feet below the top of it. The Comstock Lode, Nevada, is noted in the bulletin as a well-known instance of the influence of hot volcanic material below the surface in raising the geothermal gradient. In the state of Washington heat from old lava flows is assumed to be the cause of unusually hot flows of water from wells. Unusually low gradients in the northern Peninsula of Michigan have been ascribed to the proximity of Lake Superior.

Automobile

Production Costs in England.—Interesting comment on the increased costs of production in England is contained in the house organ of a Nottingham automotive manufacturer. He states that mechanics' wages have increased over 200 per cent, laborers' wages 300 per cent, and apprentices' wages 240 per cent. Similar increases have occurred in the prices of materials, lumber costs having increased 210 per cent, iron castings 235 per cent, steel 185 per cent, stampings 215 per cent and aluminum 175 per cent.

Recovering an Automobile Top.—It is no longer necessary for the motorist to take his car to a trimmer or to any shop to have the top repaired or renewed. A new cover for the top can be purchased, made up in such a manner that one can put it on one's self without very much effort. These new covers are all sewed together complete with tacks, curtain fasteners, binding, welts and with printed instructions telling just how to take off the old cover and apply the new. It is so simple and prices are so low that a saving of fully 50 per cent is made on the price of a new top. A perfect fit is guaranteed when the correct name, year and model number is given of the car the new cover is wanted for. Covers are tailored to fit that car and are made in sufficient variety to fit every kind of car that was ever built, so the makers claim.

Spark Plug Sold Under Three-Year Guarantee.—So firmly convinced is a prominent spark plug concern that their spark plug is unbreakable, that they have inaugurated an extensive national advertising campaign which is now being conducted through the various channels of publicity to the trade and motoring public stating that they fully guarantee each plug against breakage and defective workmanship for a period of three years. Hereafter every spark plug purchaser will receive a signed guarantee bond with each plug. If, within a period of three years from date of sale this plug should break or prove defective through no fault of the owner, it will be replaced absolutely free of charge if mailed together with the proper signed bond direct to the nearest branch or to the factory. This proves how thoroughly various automotive products have been developed and shows how one part that formerly gave considerable trouble has been improved to the point where such a broad guarantee can be given.

Truck Legislation and Food Costs.—It is estimated that during the past year approximately 350,000,000 tons of farm products were hauled to market in motor trucks by the farmers and gardeners of the United States, and the actual operating figures show that motor truck transportation is twice as cheap as horse drawn transportation. Thus it will be seen, says a prominent manufacturer, that legislation which hits motor trucks hits at the very source of the life supply of the people; to unwisely legislate against the motor truck is to take food away from those who need it and to increase its cost. Much of this 350,000,000 tons of food products hauled from the farm to the city by trucks was of a perishable nature, and hundreds of thousands of tons of it would have been lost but for the rapid transportation possible with the motor truck. The motor truck serves the needs of the people and it is for the people, both producers and consumers, to see that the motor truck is given a square deal and is not discriminated against.

Code of Approval Signals. — Register of Motor Vehicles Frank A. Goodwin of Massachusetts has approved a series of hand signals for power vehicle drivers which are practically the same as have been approved by the state officials of Connecticut, and the Massachusetts Safe Roads Federation has undertaken to carry on a campaign of education among all who own and drive automobile cars and trucks. The signals are described as given by a driver seated at the left side of the machine, but they can be given just as well with either hand. The code is as follows: Stop; extend the left arm and hold it stationary, with all fingers extended and close together. Left turn; extend the left arm and hold it stationary, with the index finger pointing and the outer three fingers closed. Right turn; extend the left arm with the fingers extended and the palm upward and rotate it from the rear to the front. Back; extend the left arm with the fingers open and close together and the palm vertical, and move it upward and downward from a horizontal position. Turning; give the "Left Turn" signal and repeat it until the vehicle has been turned and can be driven directly ahead. When turning always drive forward and turn into and with the traffic moving in the direction opposite to line of original movement. The arm of the driver should always be extended full length and held a sufficient length of time to justify observation of the drivers following.

Open Roads All Winter

Definite Snow Removal Program in Northern and Eastern States

By M. R. Reynolds

TRUNK roads in every State west of the Mississippi and north of the Potomac, except Maine, Vermont, New Hampshire and New York, are being kept clear of snow this winter for the first time in history, and the automobilist who desires to use his passenger car or motor truck during cold weather can do so nearly, if not quite, as successfully as he could in the summer.

In the past, when highways served only their immediate locality, there were no serious consequences if the roads in the Northern States remained impassable for three to five months each winter because of snow. Sleighs took the place of wheeled vehicles while the snow was on the ground, and at points where the road was drifted full, the traffic detoured through the fields. With the coming of the automobile and motor truck, conditions have changed. Twenty-five miles now are as five in the day of the horse, and an open highway 365 days in the year is necessary.

In the transportation of many kinds of freight, motor trucks have supplanted the railway in various sections of the country. One of the principal reasons for this is that commodities can be moved short distances more quickly by truck than by train. If the truck is to retain the place it has won during the last four years, the main highways which it traverses must be kept open all winter. Modern highway transportation cannot be carried on at convenience and treated with indifference. Railroads do not abandon their shippers when snow drifts block transportation, although it would often be more profitable to stop train service until the rails are cleared by natural agencies. Railroad officials realize, however, that production stops when transportation halts, and they use every effort to move traffic with daily regularity.

Production has increased more rapidly in recent years than the capacity of the railroads, and the motor truck has stepped into the breach and made good. This is demonstrated by the increased amount of freight tonnage moved annually by motor trucks, indicative of the relatively constant freight traffic over roads which are open the year round. Rural products, particularly those of the dairy, are almost entirely dependent on the highway, and in some of the Eastern States factory interchange is now largely carried in trucks.

Heavy expenditures of money are necessary to keep the main trunk roads open in the North and West during the winter months, but in sections where the work has been carried on in former winters, its value has been so apparent that a concerted effort is being made this winter to keep the main highways in all the States north of the Potomac and west of the Mississippi open to motor transportation. The Bureau of Public Roads of the United States Department of Agriculture made a study last summer of the situation in these States with regard to snow removal. As a result of this survey, the bureau has prepared a map which shows the roads that will be kept open in Connecticut, Massachusetts, Delaware, Maryland, New Jersey, Pennsylvania, Michigan, Indiana, and Illinois. In other States, notably Ohio, snow removal is the task of the towns or counties, and while the State highway department assists in every way possible and urges the necessity of the work, it is not authorized to initiate it. Thus far, snow removal in the States in which it has been attempted has worked admirably. In event of extremely heavy snow in sections not well prepared to handle its removal, difficulty may be experienced in keeping the specified roads open, but highway commissioners learn through experience and a failure this year may be turned into eminent success next winter.

The plans for keeping the highways open in winter differ somewhat in the various States, but their actual field methods are similar. Preventing snow from drifting into the highways in objectionable quantities and its removal after it has lodged there are the two main groups of activities of the snow program. Prevention in this work, as in many other kinds, is cheaper than remedy.

Snow falls uniformly and lies as it falls when there is no wind with the snowfall. Usually, however, there is more or less drifting. Snow moved by the wind is not usually lifted far above the surface of the ground, the distance depending upon the velocity of the wind. It is then deposited on the leeside of obstructions as back of such obstructions there is a body of relatively quiet air. Almost any obstacle such as weeds, hedges, and fences will clear the air current of snow by causing it to be deposited in the relatively quiet space back of these obstructions.

The first step in preventing snow from drifting into the road is to remove from the right-of-way everything that can cause drifting. Weeds and tall grass, the most common sources of trouble, should be cut down and removed even if they are no more than a foot or two high. Hedges, trees, and tight fences made of rail, stone, or picket also may cause highways to fill with drifts. Wire fences being open offer no obstruction to the wind and do not create a condition in which snow will be deposited. Many of the obstructions which cause drifting can be readily removed, but trees and

(*Continued on page 117*)

1. A well-cleared stretch of road. 2. Ruts that are worn in the roadbed when covered with snow become miry mudholes in spring. 3. The ordinary road grader will remove a moderate cover of snow. 4. Where the fall is very heavy two trucks propel a scraper blade. 5. Ordinary drifts are amply cared for by a single truck pushing the scraper

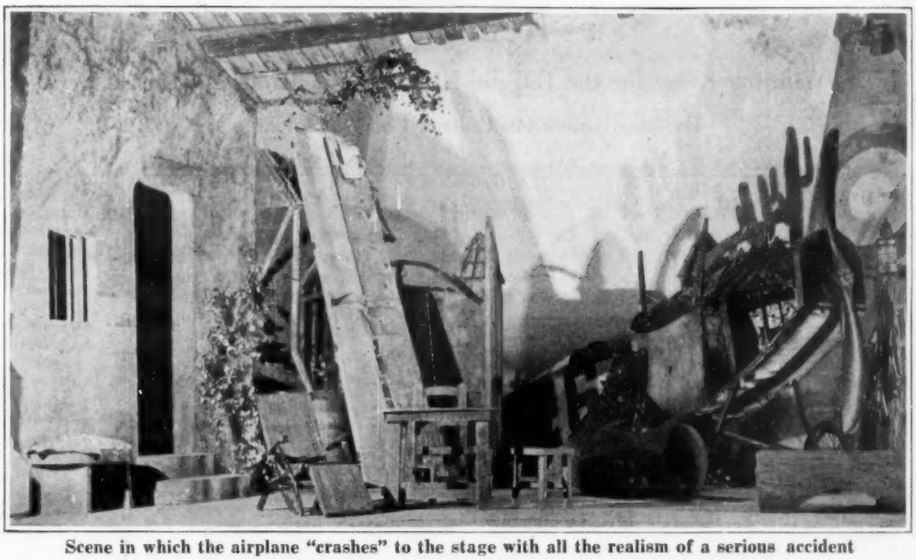
Keeping our northern roads free of snow during the winter

Stunts of the Stage

By Harry A. Mount

WHEN the theatrical producer is able to bring from his audience a gasp of astonishment and the query "I wonder how they did it?" he feels he has scored a triumph of technique. Occasionally the whole action of a play is built around some "stunt" the staging of which calls for the services of a mechanical engineer. There is one such in New York now. And in several other of the new productions mechanical genius has added some striking or surprising feature.

Practically all of the American plays are "manufactured" in New York. Many of the mechanical effects require cumbersome paraphernalia or even alterations of the stage or theater and so cannot be taken en tour. A glimpse from "back stage" at some of the thrillers along Broadway may prove interesting alike to those who will not have the opportunity to gasp at them personally and to those who will visit one or more of the productions and wonder "How is it done?"



Scene in which the airplane "crashes" to the stage with all the realism of a serious accident

"The Broken Wing" is the play referred to above. It is fabricated from the adventures of an American airman who crashes his plane in Mexico. In the first act a real airplane crashes to the stage with all the realism of a dangerous accident. Not long ago the maker of the particular airplane used in the show asked permission to view the "crash" from behind the scenes. He was readily granted permission but advised not to do it.

"It will spoil it all for you," he was told.

For this staged "crash," like many other stage effects, is mystifying chiefly because it is done so simply. It is well known that the magician often relies upon the fact that the mind usually seeks a complicated, rather than the simple and obvious explanation for what we see, to hide his tricks.

In this case a carefully selected rope is attached to the airplane in such a way that it breaks just before the machine strikes the stage and takes up most of the shock of fall. The wings are loosely fastened so that they break off when the rope snaps. The airplane is complete with its engine but the compression has been relieved and the propeller is given a whirl just as the machine starts its drop. It carries two men in its plunge to the stage and a real airplane motor roaring in the wings, up until the instant of the fall, makes the illusion convincing. A safety cable, anchored back of the stage, passes through the fuselage and around the motor so that there is no chance that the machine, weighing over a thousand pounds, will plunge into the audience. The strength of the check rope, the height of the fall, etc., have been calculated so nicely that the same machine is able to crash to the stage every day, and sometimes twice a day, with only minor repairs from time to time.

In "Sally," a new Ziegfeld production, the audience is started during a ballet scene in the last act when the whole stage, carrying a chorus of about thirty, moves forward until it covers the orchestra pit, and then glides back into place.

The mechanism of this effect also is very simple. The stage used is a double one, the upper stage being simply a low platform mounted on wheels, the forward half having no support. During the first part of the scene two wedge-shaped platforms fit snugly against the forward edge, serving to give it the appearance of a solid stage only slightly elevated and to support the forward half. Just before the stage is moved forward, these pieces are pulled into the wings. Most of the chorus is moved to the back of the stage so that it will not tilt and it is then moved forward by means of a windlass mounted beneath. A safety cable allows the stage to go forward a certain distance and then it is pulled back and the wedges slide back into place.

The New York Hippodrome is famous for its elaborate stage effects and it supplies this year perhaps the most mystifying of the "thrillers." In the final act a considerable portion of the chorus march with heads erect, like soldiers on dress parade, down a set of steps into the great bathing pool with which the stage is equipped. They sink down step by step until the crowns of their heads finally disappear beneath the water. The strange part is that they do not come to the surface. Apparently they have been swallowed up or dissolved by the water.

From "back stage" one sees quite a different performance. As each girl sinks beneath the water she dives and swims beneath the water to the front of the tank and then comes to the surface under a shield dropping from the footlights. They walk to the side

(*Continued on page 118*)

The World War on Rats

By George Gaulois

PRACTICALLY the entire world is participating in a new war. Because of the humdrum nature of this gigantic conflict, little has been heard of it by the man in the street. There are no spectacular bombardments or tank attacks or brilliant generals to talk about, to be sure; yet the world's foremost scientists, doctors, engineers and government authorities have enlisted in the ranks of the combatants, and millions upon millions of dollars are being expended in order that a decisive victory may be scored by humanity.

In brief, this world-wide war is on rats. And when we say rats, we have said plagues and diseases and other disagreeable things that can be blamed on the world's rats.

Now the queer feature of this war is that the rats are not altogether to blame. They simply are the agents for the ultimate enemy. They carry the lice on their hairy coats; and the lice, in turn, carry the bacilli which are the true and ultimate trouble makers. The rats bring the lice to the living quarters of man, and the lice in due course attempt to attach themselves to man. It is by stinging man that the lice introduce the dangerous bacilli into man's system, thus completing the chain of events which are the bottom of many plagues.

Of rats there are a great many. It is estimated that in Paris alone there are over five million rats—considerably more than the human population. The damage caused by these rats is too well known to require elaboration; a person of mathematical mind might find much diversion in calculating how much food such a vast colony of rats consumes a year.

The war on rats may be conducted on an offensive or defensive basis, depending upon conditions. In offensive operations the character of the work varies according to whether the rats are hunted in the open or in spaces capable of being hermetically sealed. Obviously, the best methods are those which destroy the lice as well as the rats, for there is little gained if the lice are permitted to seek refuge on man or nearby animals.

In places capable of being hermetically sealed, recourse is had to asphyxiating gas, and as a rule sulfurous gases are employed. The heavy gases are directed into corners in order that they may sink down into rat holes and hidden places. The operation terminated, the space is energetically ventilated to render the atmosphere normal and to prevent the deterioration of various surfaces, which are often affected especially when warm and humid gases are used. The last traces of gas can be destroyed by vaporizing ammonia.

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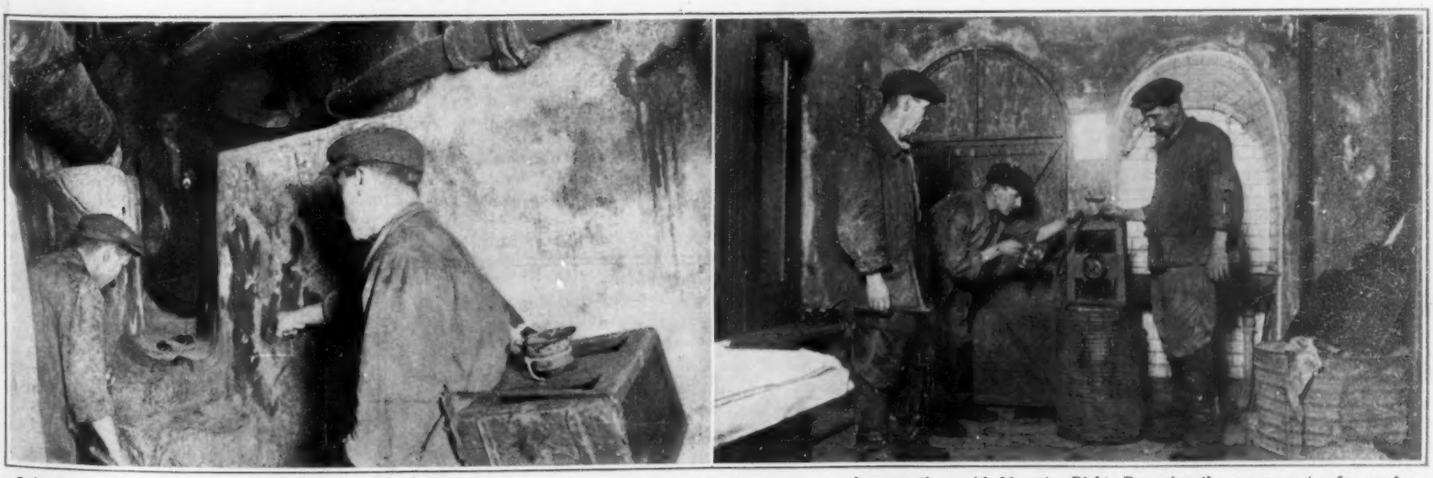


Left: An electric flash lamp serves to blind the rats in this underground passageway while one of the hunters swoops down on them with his net. *Right:* Preparing the gas generator for gassing the rats in a hermetically sealed space. The men shown in both these views are professional rat hunters, undertaking contracts for ridding institutions of rats

With the rat hunters of Paris. These men have made rat hunting a profession and receive high remuneration for their efforts

Relativity

The Winning Essay for the Eugene Higgins Five Thousand Dollar Prize

By "Zodiaque" (L. Bolton, London, England)

IN their work of gradual elimination of those essays which were not the best, the Einstein Judges found that by all means the most effective test to apply was that which arises from the fact that when a man writes about the Einstein theories in 3,000 words, the most momentous problem confronting him is what to leave out. Examination of the essays brought to light without much difficulty about twenty that stood out well above the others in this regard. Mr. Bolton's winning essay is the example par excellence of this merit of advantageous selection. Everybody will of course agree that he says admirably what he has to say; but the real reason why his essay was ultimately chosen over its most pressing rivals was the extraordinarily fine judgment which he used in deciding just what he would say and what he would leave unsaid. We do not believe it would be possible to make any material improvement upon Mr. Bolton's selection of the ground to be covered in an essay of this character.—THE EINSTEIN EDITOR.

THE reader is probably acquainted with the method of specifying positions of points in a plane by their distances from two mutually perpendicular lines, or if the points are in space by their distances from three mutually perpendicular planes like adjacent sides of a flat-sided box. The method is in fact in common use for exhibiting relations between quantities by graphs or diagrams. These sets of axes, as they are called, together with any scales used for measuring, must be supposed rigid, otherwise the events or points which they are used to specify are indefinite. The lengths which locate any point with reference to a set of axes are called its coördinates.

When such systems are used for physical purposes, they must be supplemented by clocks to enable the times at which events occur to be determined. The clocks must be synchronized, and must go at the same rate, but it must suffice here to state that this is possible without indicating how these conditions can be attained. A system of axes with its clocks will hereinafter be called a Frame of Reference, and every observer will be supposed to be provided with such a frame partaking of his motion. All the objects which partake of an observer's motion will be called his *system*.

It is a question whether among all possible frames of reference any one frame or class of frames is more suited than another for the mathematical statement of physical laws. This is for experience to decide, and a Principle of Relativity is a statement embodying the answer.

The Mechanical Principle of Relativity

It has been ascertained that all such frames are equally suitable for the mathematical statement of general *mechanical* laws, provided that their motion is rectilinear and uniform and without rotation. This fact is comprehended in the general statement that *all unaccelerated frames of reference are equivalent for the statement of the general laws of mechanics.* This is the mechanical principle of relativity.

It is well recognized however that the laws of dynamics as hitherto stated involve the following assumptions:

(1) Lengths of rigid bodies are unaffected by the motion of the frame of reference.

(2) Measured times are likewise unaffected.

That is to say that any length measured on his own system by either of two relatively moving observers appears the same to both observers, or that lengths of objects and rates of clocks do not alter whatever the motion relative to an observer. These assumptions seem so obvious that it is scarcely perceived that they are assumptions at all. Yet this is the case, and as a matter of fact they are both untrue.

The Special Principle of Relativity

Although all unaccelerated frames of reference are equivalent for the purposes of mechanical laws, this is not the case for physical laws generally as long as the above suppositions are adhered to. Electromagnetic laws *do* alter their form according to the motion of the frame of reference; that is to say, if these suppositions are true, electromagnetic agencies act in different ways according to the motion of the system in which they occur. There is nothing *a priori* impossible in this, but it does not agree with experiment. The motion of each locality on the earth is continually changing from hour to hour but no corresponding changes occur in electromagnetic actions. It has however been ascertained that on discarding these suppositions the difficulty disappears, and electromagnetic laws retain their form under all circumstances of unaccelerated motion. According to the theory of relativity, the correct view which replaces these suppositions is deducible from the following postulates:

(1) By no experiment conducted on his own system can an observer detect the unaccelerated motion of his system.

(2) The measure of the velocity of light *in vacuo* is unaffected by relative motion between the observer and the source of light.

Both these postulates are well established by experiment. The first may be illustrated by the familiar difficulty of determining whether a slowly moving train one happens to be sitting in, or an adjacent one, is in motion. The passenger has either to wait for bumps (that is, accelerations) or else he has to look out at some adjacent objects which he knows to be fixed, such as a building (that is, he has to perform an experiment on something outside his system), before he can decide.

The second postulate is an obvious consequence of the wave theory of light. Just as waves in water, once started by a ship, travel through the water with a velocity independent of the ship, so waves in space travel onward with a speed bearing no relation to that of the body which originated them. The statement however is based on experiment, and can be proved independently of any theory of light.

It is not difficult to deduce from these postulates certain remarkable conclusions relating to the systems of two observers, A and B, in relative motion, among them the following:

(1) Objects on B's system appear to A to be shorter in the direction of relative motion than they appear to B.

(2) This opinion is reciprocal. B thinks that A's measurements on A's system are too great.

(3) Similarly for times: each observer thinks that the other's clocks have a slower rate than his own, so that B's durations of time appear shorter to B than to A, and conversely.

(4) Events which appear simultaneous to A do not in general appear so to B, and conversely.

(5) Lengths at right angles to the direction of motion are unaffected.

(6) These effects vary with the ratio of the relative velocity to that of light. The greater the relative velocity, the greater the effects. They vanish if there is no relative velocity.

(7) For ordinary velocities the effects are so small as to escape notice. The remarkable point however is their occurrence rather than their magnitude.

(8) The observers similarly form different estimates of the velocities of bodies on each other's systems. The velocity of light however appears the same to all observers.

Taking into account these revised views of lengths and times the mechanical principle of relativity may be extended to physical laws generally as follows: *All unaccelerated frames of reference are equivalent for the statement of the general laws of physics.* In this form the statement is called the Special, or Restricted, Principle of Relativity, because it is restricted to unaccelerated frames of reference. Naturally the laws of classical mechanics now require some modification, since the suppositions of unalterable lengths and times no longer apply.

The Four Dimensional Continuum

Lengths and times therefore have not the absolute character formerly attributed to them. As they present themselves to us they are relations between the object and the observer which change as their motion relative to him changes. Time can no longer be regarded as something independent of position and motion, and the question is what is the reality? The only possible answer is that objects must be regarded as existing in four dimensions, three of these being the ordinary ones of length, breadth and thickness, and the fourth, time. The term "space" is applicable only by analogy to such a region; it has been called a "continuum," and the analogue of a point in ordinary three-dimensional space has been appropriately called an "event." By "dimension" must be understood merely one of four independent quantities which locate an event in this continuum. In the nature of the case any clear mental picture of such a continuum is impossible; mankind does not possess the requisite faculties. In this respect the mathematician enjoys a great advantage. Not that he can picture the thing mentally any better than other people, but his symbols enable him to abstract the relevant properties from it and to express them in a form suitable for exact treatment without the necessity of picturing anything, or troubling whether or not the properties are those on which others rely for their conceptions.

Gravitation and Acceleration

The limitation of statements of general law to uniformly moving systems is hardly satisfactory. The very concept of general law is opposed to the notion of limitation. But the difficulties of formulating a law so that the statement of it shall hold good for all observers, whose systems may be moving with different and possibly variable accelerations, are very great. Accelerations imply forces which might be expected to upset the formulation of any general dynamical principles, and besides, the behavior of measuring rods and clocks would be so erratic as to render unmeaning such terms as rigidity and measured time, and therefore to preclude the use of rigid scales, or of a rigid frame of reference which is the basis of the foregoing investigation.

The following example taken from Einstein will make this clear, and also indicate a way out of the difficulty. A rotating system is chosen, but since rotation is only a particular case of acceleration it will serve as an example of the method of treating accelerated systems generally. Moreover, as it will be seen, the attribution of acceleration to the system is simply a piece of scaffolding which can be discarded when the general theory has been further developed.

Let us note the experiences of an observer on a rotating disk which is isolated so that the observer has no direct means of perceiving the rotation. He will therefore refer all the occurrences on the disk to a frame of reference fixed with respect to it, and partaking of its motion.

He will notice as he walks about on the disk that he himself and all the objects on it, whatever their constitution or state, are acted upon by a force directed away from a certain point upon it and increasing with the distance from that point. This point is actually the center of rotation, though the observer does not recognize it as such. The space on the disk in fact presents the characteristic

WE, the Judges in the Einstein Prize Essay Contest, hereby state that it is our united judgment that the essay "Relativity," submitted under the nom de plume "Zodiaque," is the best essay received within a proper interpretation of the conditions and aims of the contest; and we award to its author the prize of $5,000 offered by Mr. Eugene Higgins of Paris.

Leigh Page
E. P. Adams.

properties of a gravitational field. The force differs from gravity as we know it by the fact that it is directed away from instead of toward a center, and it obeys a different law of distance, but this does not affect the characteristic properties that it acts on all bodies alike, and cannot be screened from one body by the interposition of another. An observer aware of the rotation of the disk would say that the force was centrifugal force; that is, the force due to inertia which a body always exerts when it is accelerated.

Next suppose the observer to stand at the point of the disk where he feels no force, and to watch someone else comparing, by repeated applications of a small measuring rod, the circumference of a circle having its center at that point, with its diameter. The measuring rod when laid along the circumference is moving lengthwise relatively to the observer, and is therefore subject to contraction by his reckoning. When laid radially to measure the diameter this contraction does not occur. The rod will therefore require a greater proportional number of applications to the circumference than to the diameter, and the number representing the ratio of the circumference of the circle to the diameter thus measured will therefore be greater than 3.14159+, which is its normal value. Moreover the relative velocity decreases as the center is approached, so that the contraction of the measuring rod is less when applied to a smaller circle; and the ratio of the circumference to the diameter, while still greater than the normal, will be nearer to it than before, and the smaller the circle the less the difference from the normal. For circles whose centers are not at the point of zero force the confusion is still greater, since the velocities relative to the observer of points on them now change from point to point. The whole scheme of geometry as we know it is thus disorganized. Rigidity becomes an unmeaning term since the standards by which alone rigidity can be tested are themselves subject to alteration. These facts are expressed by the statement that the observer's measured space is non-Euclidean; that is to say, in the region under consideration measurements do not conform to the system of Euclid.

The same confusion arises in regard to clocks. No two clocks will in general go at the same rate, and the same clock will alter its rate when moved about.

The General Principle of Relativity

The region therefore requires a space-time geometry of its own, and be it noted that with this special geometry is associated a definite gravitational field, and if the gravitational field ceases to exist, for example if the disk were brought to rest, all the irregularities of measurement disappear, and the geometry of the region becomes Euclidean. This particular case illustrates the following propositions which form the basis of this part of the theory of relativity:

(1) Associated with every gravitational field is a system of geometry, that is, a structure of measured space peculiar to that field.
(2) Inertial mass and gravitational mass are one and the same.
(3) Since in such regions ordinary methods of measurement fail, owing to the indefiniteness of the standards, the systems of geometry must be independent of any particular measurements.
(4) The geometry of space in which no gravitational field exists is Euclidean.

The connection between a gravitational field and its appropriate geometry suggested by a case in which acceleration was their common cause is thus assumed to exist from whatever cause the gravitational field arises. This of course is pure hypothesis, to be tested by experimental trial of the results derived therefrom.

Gravitational fields arise in the presence of matter. Matter is therefore presumed to be accompanied by a special geometry, as though it imparted some peculiar kink or twist to space which renders the methods of Euclid inapplicable, or rather we should say that the geometry of Euclid is the particular form which the more general geometry assumes when matter is either absent or so remote as to have no influence. The dropping of the notion of acceleration is after all not a very violent change in point of view, since under any circumstances the observer is supposed to be unaware of the acceleration. All that he is aware of is that a gravitational field and his geometry coexist.

The prospect of constructing a system of geometry which does not depend upon measurement may not at first sight seem hopeful. Nevertheless this has been done. The system consists in defining points not by their distances from lines or planes (for this would involve measurement) but by assigning to them arbitrary numbers which serve as labels bearing no relation to measured distances, very much as a house is located in a town by its number and street. If this labeling be done systematically, regard being had to the condition that the label-numbers of points which are close together should differ from one another by infinitesimal amounts only, it has been found that a system of geometry can actually be worked out. Perhaps this will appear less artificial when the fact is called to mind that even when standards of length are available no more can be done to render lengths of objects amenable to calculation than to assign numbers to them, and this is precisely what is done in the present case. This system of labeling goes by the name of "Gaussian coördinates" after the mathematician Gauss who proposed it.

It is in terms of Gaussian coördinates that physical laws must be formulated if they are to have their widest generality, and the general principle of relativity is that *all Gaussian systems are equivalent for the statement of general physical laws.* For this purpose the labeling process is applied not to ordinary space but to the four dimensional space-time continuum. The concept is somewhat difficult and it may easily be aggravated into impossibility by anyone who thinks that he is expected to visualize it. Fortunately this is not necessary; it is merely one of these irrelevancies to which those who are unaccustomed to think in symbols are liable.

It will now be seen that among physical laws the law of gravitation stands pre-eminent, for it is gravitating matter which determines the geometry, and the geometry determines the form of every other law. The connection between the geometry and gravitation is the law of gravitation. This law has been worked out, with the result that Newton's law of the inverse square is found to be approximate only, but so closely approximate as to account for nearly all the motions of the heavenly bodies within the limits of observation. It has already been seen that departure from the Euclidean system is intensified by rapidity of motion, and the movements of these bodies are usually too slow for this departure to be manifest. In the case of the planet Mercury the motion is sufficiently rapid, and an irregularity in its motion which long puzzled astronomers has been explained by the more general law.

Another deduction is that light is subject to gravitation. This has given rise to two predictions, one of which has been verified. The verification of the other is as yet uncertain, though the extreme difficulty of the necessary observations may account for this.

Since light is subject to gravitation it follows that the constancy of the velocity of light assumed in the earlier part of this paper does not obtain in a gravitational field. There is really no inconsistency. The velocity of light is constant in the absence of gravitation, a condition which unaccelerated motion implies. The special principle of relativity is therefore a limiting case of the general principle.

ALIKE from the nature of the subject, from the fact that Dr. Eddington has written a rather bulky book about it, and for that matter from our remarks on the opposite page, it should be clear to the reader that Mr. Bolton has by no means exhausted or attempted to exhaust his subject. A few of the very best of the competing essays we shall print in full in subsequent issues of the SCIENTIFIC AMERICAN *and the* SCIENTIFIC AMERICAN MONTHLY*; but a few only. We shall, on the other hand, print portions of and extracts from a comparatively large number. The aim will be to set before our readers everything of real value which the contest has brought out; but to use no more space in duplication than is unavoidable, and to print nothing that requires any serious editorial questioning. Many of the excerpts which will thus appear will cover points which Mr. Bolton leaves untouched; many will develop more fully or to better advantage points on which he leaves something to be desired in either of these respects. We shall emphasize at all times that Mr. Bolton's essay is not the only thing of value that has come out of the contest, and that no reader can do justice to the relativity theories by reading it and ignoring the others. In publishing other essays or parts of essays, and even in calling specific attention to the points in which they add to or improve upon Mr. Bolton's essay, we are in no sense criticising the latter, or saying anything on which a just complaint against the award of the Judges may be based.*—THE EINSTEIN EDITOR.

Some Einstein Contest Personalities

By the Einstein Editor

IT IS appropriate at this time to say a word in regard to Mr. Eugene Higgins, the donor of the splendid prize of $5,000 for the best essay on the Einstein Theory of Relativity, which was announced for the first time in this paper some months ago.

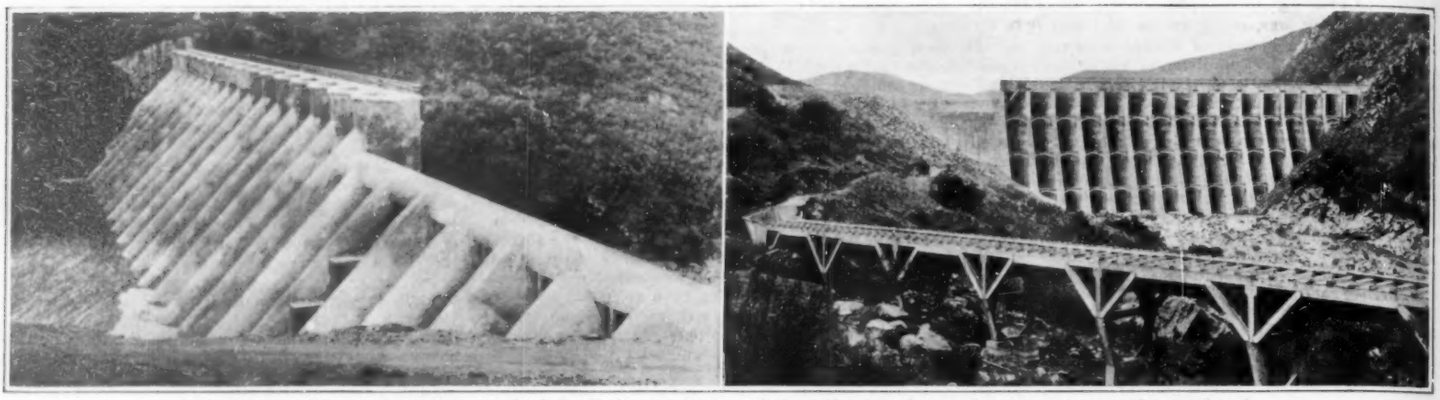
Mr. Higgins is a graduate of Columbia University; was brought up in New York and lived here for many years. He is a bachelor, with the freedom that all that implies; and with no special ties to keep him in this country he has traveled extensively abroad. He has a handsome residence on the banks of the Seine, in the city of Paris, and makes occasional trips to this country to look after his interests here. He is a gentleman of refinement and culture, interested in all that pertains to intellectual life, and particularly to physics and mathematics. It is his interest in this particular line of work which has prompted him to offer this magnificent prize for the best essay on the subject of Relativity.

It has never been announced, but perhaps it is appropriate at this time to state that it was Mr. Higgins who some years ago offered a prize of $500 for a mathematical essay which was published in the SCIENTIFIC AMERICAN at that time. It was his wish that his name should not in any way be connected with the last mentioned gift to the development of science. This is in entire harmony with his character, which is one of self-effacement; it was only after considerable persuasion that he allowed his name to be used in connection with the present prize. It goes without saying that he has absolutely no ulterior motive beyond his desire for the advancement of scientific knowledge in general.

It is hardly necessary for us to mention to our readers the fact that these prizes have been offered by Mr. Higgins without any prompting or suggestion on our part. It has been thought by the Editor that it would not be proper for us to make this announcement, however, without having these facts thoroughly understood by our readers. We venture to follow this attitude without the knowledge of Mr. Higgins, with whom we have no opportunity of communicating as to his wishes except by cable.

We regret that at the present time it is not possible for us to supplement this information about the donor of the prize with a similar statement about the winner. Mr. Bolton, we suppose, may fairly be called unknown in a strictly scientific sense, though he is a professional man of distinction in his field. He is on the staff of the British Patent Office, in a position which we are unable to define exactly at this writing, but which is one of rank. It will be recalled that Einstein himself was in the Swiss Patent Office for some years.

That Mr. Bolton did not take the prize through default of serious competition will be evident from a brief mention of a few of his most distinguished competitors. Dr. William H. Pickering of the Harvard Observatory in Jamaica; our own Dr. Russell, Royal Astronomical Society medalist for the year; and Dr. William de Sitter, the distinguished Netherlander, are among the astronomers of note who took part in the contest. Other continental competitors were Schlick, author of "Space and Time in Contemporary Physics," and Becquerel, who should need no word of introduction. Perhaps the most distinguished British name which was given up by any of the little sealed envelopes was that of H. H. Turner, of Oxford; others were Dr. E. N. da C. Andrade, Professor of Physics in the Ordnance College at Woolwich, and Dr. T. Royds, of the Kodaikanal Observatory in southern India. Among American physicists we find the names of Prof. H. F. Moore, of the University of Illinois; Dr. J. S. Ames, of Johns Hopkins; Dr. W. F. Swann, of the University of Minnesota and Dr. A. G. Webster, of Clark University. Dr. G. D. Birkhoff, of Harvard, we should say heads the list of mathematicians pure and simple who competed; and we must list the well known meteorologist, Dr. Alexander McAdie, of Harvard, an occasional contributor to our columns. That even the men whose primary interest lies in the severely practical direction are not strangers to the intricacies of abstract theory is indicated by the entry of Dr. C. E. K. Mees of the giant commercial photographic laboratory at Rochester. In short, Mr. Bolton has come out at the top of a very distinguished company.



Upstream and downstream views of the Lake Hodges multiple-arch dam, showing the novel concrete construction employed

The Big Dam on the Little San Diego

A Multiple-Arch Structure of Unusual Height and Some of the Principles Involved in Its Construction

By J. F. Springer

WHETHER a multiple-arch dam is the most economical one to build turns upon the local conditions. As a rule, they grow expensive as they are made tall. The reason for this needs some explanation. A single-arch dam may have a fairly vertical face upstream; but this is not permissible when there is a plurality of arches. Naturally, the water pressure must somehow be resisted. With a single arch, the sides of the canyon receive a great part of the hydraulic thrust. These sides are in fact the supports of the arch. But this is changed when one, two or more arches are to span the stream. The arches of a multiple-arch dam uniformly exert their arch action upon the foundation. In order to do this, they must lean in such way that the crest of the dam is farther downstream—on the upstream side—than is the base. A system of braces and the like sustains the system of multiple arches. This system of braces receives the arch action and transmits it to the floor of the foundation. Now these braces and the coacting uprights, etc., constitute a more and more serious problem the higher the crest of the dam is set above the base of the structure. The width of the base may equal or exceed the height of the whole dam. With dams of moderate height, the expense of the supporting framework may be rather reasonable; but when the height goes up to considerable figures the cost is apt to be considerable, too. Nevertheless, in southern California there has been built a multiple-arch dam 136 feet high. So far as I know this is the record for this type of structure.

There are 24 flutes or arches in this dam. The end ones have almost no depth; but there are a dozen intermediate ones that reach to considerable depths. The structure is of reinforced concrete. In fact, it is doubtful whether it would be practical to use another construction material. There is nothing massive about the dam. It does not depend upon its weight to resist the water, but upon the way it receives and transmits the thrust. On one side of the ravine, the bank has been leveled off for about 192 feet. This bench or ledge provides part of the spillway section for the dam, the remainder, 168 feet, being a rollway over the top of one end of the concrete dam. The concrete structure fills the ravine from side to side, and is 558 feet long.

The site is inland from San Diego at a point on the San Dieguito River about 30 miles distant. Back of the dam has been created a reservoir having a capacity of some 13,000,000,000 gallons. The water impounded is to be used for irrigation purposes in the semi-arid coast lands lying between Del Mar and Oceanside and on the road connecting Los Angeles and San Diego. The rainfall is insufficient for the growth of regular crops. The dam has the duty of impounding the river water, which is then piped to desired points of use. Part of the land served is a total of some 12,000 acres whose value was less than $1 per acre. In short, the land was practically waste. Water was supplied first in 1919. One man put 28 acres in potatoes and harvested them in February, 1920. They brought when sold something over $28,000. So the land itself appears to promise well.

Not only is the dam of concrete; but a flume and pressure pipe have been constructed of the same materials. Apparently a chief factor in selecting concrete for the flume and pipe rather than wood is the desirability, or perhaps necessity, of using something that will not burn. Fires in the brush have caused a good deal of trouble, but they will naturally not do much to the concrete.

The cost of the dam, exclusive of accessory structures, has been about $4,000,000. Its site is some 10 miles from the mouth of the river. The flutes or arches are supported by 25 buttresses which are spaced at intervals of 24 feet, center to center. At the bottom the buttresses are much thicker than at upper levels. That is, at the very bottom, the thickness is 4 feet. This thickness is decreased gradually to 1½ feet at the level, 63 feet above the stream. From this level up, the thickness remains undiminished. All this is testimony to the heavy pressures that have to be resisted at the lower levels. The curvature of the arches is on a circle having a radius of 13 feet 10¼ inches. This is on the upstream face. On the downstream face, the curvature varies, especially in the lower levels, with the height above stream. However, from a level 75 feet above the bed of the stream bed on up the arches each have uniform thickness. I have said that the structure is of reinforced concrete; but this is not entirely correct. The buttresses are without reinforcement. The arches, on the contrary, are reinforced both horizontally and up and down along the slant. The reinforcement is anchored in the upstream side of the buttresses. Moreover, the reinforcement is so located in the arches as to form a kind of "fabric" near the outer and also near the inner surface. The concrete in the arches is an especially rich mixture (1:2:4); that in the buttresses is nearly as rich (1:2½:5). The upstream face of the arches was given a coating by the use of an apparatus which throws a jet of mortar or grout.

The spillway, consisting in part of one end of the concrete dam and in part of the rock ledge, is altogether 360 feet long and is 15 feet lower than the crest of the main portion of the concrete structure. It seems that the maximum flow accurately known was a flood of 72,100 second-feet. The requirement was imposed by the State that the spillway should provide for the passage of this flow. Hence the cut into the side of the ravine. A tunnel in line with the length of the dam has been constructed underneath the spillway. It is 192 feet long and 4 x 6½ feet in cross-section. It is concrete lined. Its purpose is to provide for access to the control valves underneath the dam. At its terminus, on the stream side, the tunnel connects with a series of concrete foot bridges which extend through the remainder of the dam. From these bridges in the buttresses, the blowoff and service gates may be operated. All this provision is especially for use during high water. Control might have been arranged at the crest; but then a bridge would have been needed along and over the spillway. The objection to this is that the necessary piers would cut down the capacity of the spillway to pass the 70,000 second-feet.

During the low water periods there is access through the downstream face of the spillway for the operators, admitting to the control chamber for the irrigation supply. Here the water is turned on and off. There are half a dozen outlet gates, so set as to draw water from the lake at vertical intervals of 10 feet. Each of these gates has its individual pipe-connection with the irrigation main-conduit. These pipes are of strongly reinforced concrete and are bedded on the rock and secured to the buttresses. At the very lowest region of the dam are several blow-off valves. To reach the control device, the operator comes down a concrete stairway extending down from one of the foot bridges already mentioned.

When filled to capacity, the dam will restrain a lake 115 feet deep. The 30,000 acre-feet of water stored here is to be used at more or less distant points. There is a conduit 4½ miles long which serves to carry the water toward the coast. It consists of a ditch which has been lined with concrete. At places, the conduit is covered with concrete slabs, the object in view being to prevent the invasion of rocks rolling down the mountain side. There are a number of inverted siphons. These are used to get the water across ravines or other depressions. Some of these are, at their lower part, under a pressure corresponding to a 90-foot head—that is, to 39 pounds pressure per square inch. There is also an amount of steel flume. The steel flume and the lower parts of the concrete siphons are carried by concrete trestles. The siphons are 42 inches in diameter and are reinforced. The trestles have been constructed of pre-cast interchangeable units. It is said that the cost of the trestles was much less because of this substitution for the ordinary method which proceeds by pouring the concrete *in situ*.

The dam which impounds the water is Hodges Dam and the body of water Lake Hodges. The conduit delivers to a second lake which is known as San Dieguito Reservoir. This second lake is created by another multiple-arch dam. It is 50 feet high and 650 feet long. Concrete

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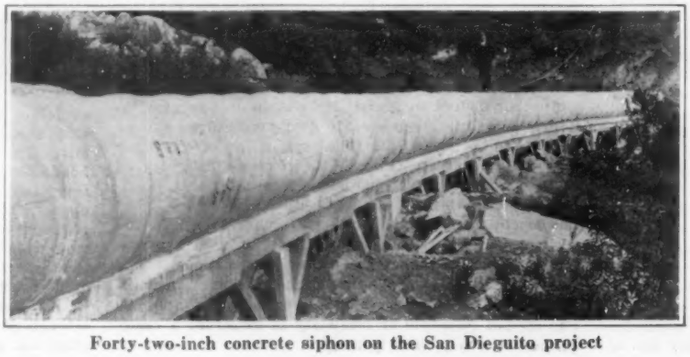

Forty-two-inch concrete siphon on the San Dieguito project

Clearing Away the Scars of War

THE recent war, considered in an atmosphere three thousand miles away from the former battlefields, may be an old story. But to those who have had to live in the shambles of the great conflict, the war is by no means over so far as its effects are concerned.

Thanks to the courtesy of President Andre Tardieu of the Comité des Régions Dévastées, we are enabled to present a number of striking facts and figures concerning the gigantic task facing the French people, and what progress they have already made despite the serious limitations imposed by lack of sufficient finances, scarcity of coal, and absence of German assistance.

Of 2,728,000 persons driven out of the devasted region by the invading armies, 2,023,000 have returned. The war caused the destruction of 4,068 municipalities, of which number 4,006 have been re-established. Before the war there were 6,445 schools in the devasted region; today 5,345 have been re-established. In all, 574,777 houses were either entirely destroyed or at least half destroyed. By last June the French had rebuilt 13,100 houses, repaired 178,500 houses, and erected 46,570 temporary structures. These structures afforded shelter to 887,000 inhabitants; the rest of the population in the devastated region have been living in such houses as remained undestroyed. The problem of rebuilding is a two-fold one: first, the land must be cleared away, and, secondly, the rebuilding must be carried on with such materials and labor as are available. In many instances the ruins are such that it is not feasible to clear them away. One cannot imagine what a destroyed town means in terms of broken stone, loose brick, piles of plaster, shattered glass, and huge, deep holes. To remove such a mass of débris is often more difficult and costly than to select a new site and build a new town from the ground up.

Of arable lands, the war ruined 9,810,000 acres, of which 8,068,000 acres have been cleared of projectiles, and 6,687,000 of iron wire. The French have plowed 3,756,000 acres; 134,000,000 cubic meters of trenches have been filled in, and 182,000,000 cubic meters of iron wire networks have been cleared away.

The war destroyed 1,397 miles of standard gage, and 1,483 miles of local track. Of this mileage, only 737 miles had been replaced up till last April. Of the French canals, 992 miles were destroyed, and 488 miles have been repaired. The roads suffered heavily, 32,031 miles being destroyed. The French have repaired 1,215 miles and improved 9,962 miles. Of factories, the war destroyed 11,500. Since the termination of hostilities the French have re-established 3,540 factories, which are now operating, and 3,812 are being rebuilt.

A New Sweet Clover Harvester

AS a soil builder sweet clover is rapidly gaining favor in all parts of the country. The great drawback to a more universal use, in one sense, has been the lack of adequate machinery to harvest the seed for planting or sowing purposes. Until lately the only way to obtain the seed was to cut the crop with a binder or mower and thresh in a clover huller, and should the residue be returned to the land it would be difficult to plow under with satisfactory results. With a new harvester invented by an Illinois man it is now possible to remove the seed and the plant is left standing to be plowed under in order thoroughly to enrich the soil.

Virtually the machine is pushed through the clover field, when in operation, by four horses, while two men operate it. One man tends to the screening and sacking while the other drives the team. The machine is carried by two wheels while the end of the tongue is supported by a center wheel to facilitate turning at corners. A chain sprocket on the larger axle drives an overhead shaft bearing four large paddle or threshing wheels at a high speed. Parting guides compact the stalks as they are drawn through a series of fin shaped paddles, some rigid, others mounted on the sides of the threshing wheels. These notched paddles mesh loosely. The stalks of the plant are stiff when the seed is ripe and upon being drawn through are bent into series of angles which hold while the seed is beaten off. A draft of air drops the seed into conveyors that carry it back to a bin, where it is screened and sacked. A nine foot swath is taken by the machine in the field being harvested. The mechanism is easily raised or lowered as it is necessary.

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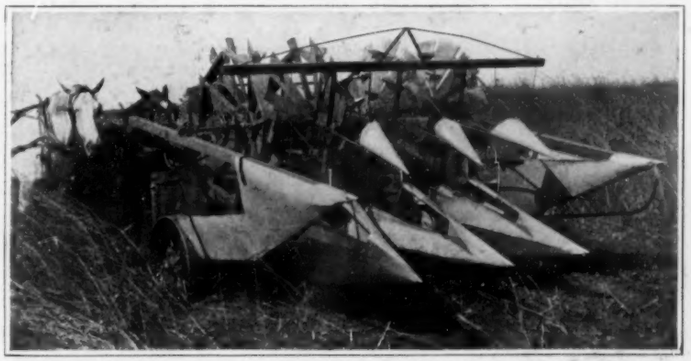
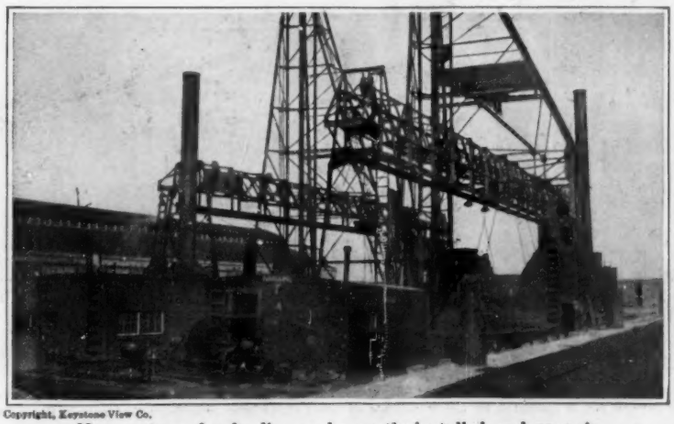
Reconstructed Verdun, showing the library and print shop. Most of the rebuilding in France is in the form of frame construction

All these logs represent but one Douglas fir tree, a species that often attains a height of 250 to 300 feet



This machine strips the clover plants of the seed but leaves the plant standing



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New system of unloading coal recently installed on barges in San Francisco Harbor

Scientific American Monthly for February

"ONLY the other day some dull and tedious occupant of a professor's chair solemnly remarked that the metrologist must be compared to the plow-horse, patiently digging his furrow, while the man of new and original ideas is the race-horse, swiftly covering space to the plaudits of an admiring crowd. The metaphor is not entirely displeasing to me, for when once the race is over, what is there to show for it, but a little dust and a little noise, while in the furrow traced by the steady plow-horse, the coming harvest will tomorrow lift its head." Thus spake M. Charles Edouard Guillaume, winner of the Nobel Prize for Physics, in an interview for the SCIENTIFIC AMERICAN MONTHLY. M. Guillaume is the director of the International Bureau of Weights and Measures, located at St. Cloud. The article proceeds to describe the interesting apparatus developed and employed at that famous Bureau.

Fifteen years ago Vesuvius blew off its head in a very violent eruption. Since then it has been gradually building up a new cone on the floor of the old crater. The process has been studied by Frank A. Perret, the well known volcanologist, and he explains this bit of volcanic archi-

(*Continued on page 120*)

A Tree to the Train Load

DOUGLAS fir is the name given to one of the finest timber trees in the western part of the United States. And it doesn't require more than one tree to make a train load, when one is dealing with Douglas fir.

Proof of this is found in the accompanying illustration which shows such a tree cut into car lengths for convenience of transportation. The diameter of the log in the foreground is 10 feet 7 inches. That is by no means an extraordinary growth, for specimens with a diameter of 15 feet are common, and travelers in the belt where they grow report having seen them 20 feet in diameter and tapering straight to a height of from 250 to 300 feet.

The Coast Range of the Sierras provides the best trees. Only the famous redwood and two or three other growths exceed the fir in size, and none except the yellow pine produces so much commercial timber. The tree is sometimes styled the Oregon pine, but foresters say it is more of a hemlock. Its botanical name is "false hemlock," although that designation is not generally approved.

Doing Away with Hand Shoveling

THE equipment shown in the accompanying illustration has recently been installed on some barges at San Francisco, for the purpose of doing away with hand shoveling. The shape and size of the bottom of each barge are such that the clam-shell bucket can pick up every bushel of coal without the necessity of employing any men for hand shoveling. When the bucket is filled with coal, it is raised to the overhead truck and carried to the center of the barge. Here the coal is dropped into a hopper. From the latter the coal is delivered into a skip which is attached to a cable and adapted to be elevated by the cable to a great height where it is automatically dumped into a spout which delivers the coal into the bunkers of the ship.

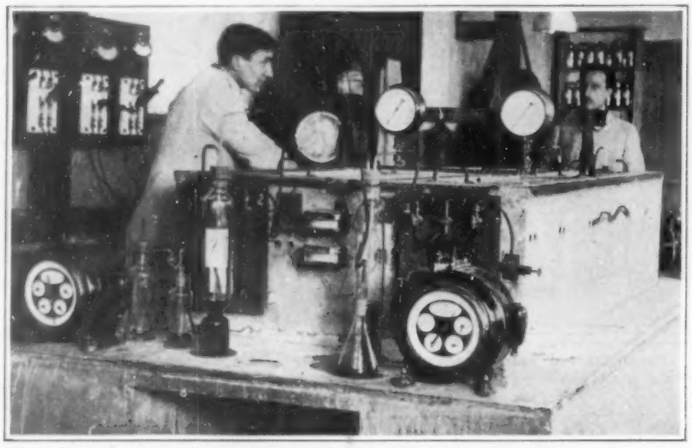
Artificial Ammonia

The Claude Process, Now in Successful Operation in France

By Jacques Boyer

THE creator of the French liquid air industry, M. Georges Claude, has just made a new and important discovery in the industrial synthesis of ammonia. The accompanying pictures show that the method requires neither complicated apparatus nor vast installations. In spite of this the inventor deals with pressures of several hundred atmospheres in order to unite nitrogen with hydrogen, pressures which artillerists alone were handling up to now, in guns of heavy caliber.

M. Claude began first by studying in his laboratory the various catalyzers which by the simple action of their presence will lead to combination of the heavily compressed and heated gases. These catalyzing substances (which M. Claude keeps a secret) are put in steel tubes placed in strong cement vats. By means of gages, recording meters and pyrometers, it is possible to watch over the reactions of the gaseous mixtures and to determine the proportions as well as the nature of the elements to be used in the industrial apparatus. Ingenious devices facilitate, besides, the cooling of the tubes containing the catalyzing substances.



The laboratory room from which, with the aid of the manometers and pyrometers shown, the processes of combining the hydrogen and nitrogen into ammonia are controlled

If one visits the factory, one sees on one side a column for the production of nitrogen extracted from the air by the liquefying process. The functioning of this apparatus is based, as is well known, upon the accumulation of cold resulting from a series of successive discharges of the compressed gas.

Elsewhere, hydrogen electrolytically produced is obtained. When this is done, the gaseous mixture of nitrogen and hydrogen is prepared in advance; great care is taken to rid this mixture of all traces of oxygen before it is allowed to pass in contact with the catalyzing matter. It is then hypercompressed at 1,000 atmospheres and metallic gages measure this pressure which is constantly maintained by regulating the admission to the hypercompressor. The small gaseous admission is regulated by means of a regulating valve placed below the tube and the percentage of ammonia is determined by allowing the outflowing gases to pass through a sulfuric solution and then through a gas meter.

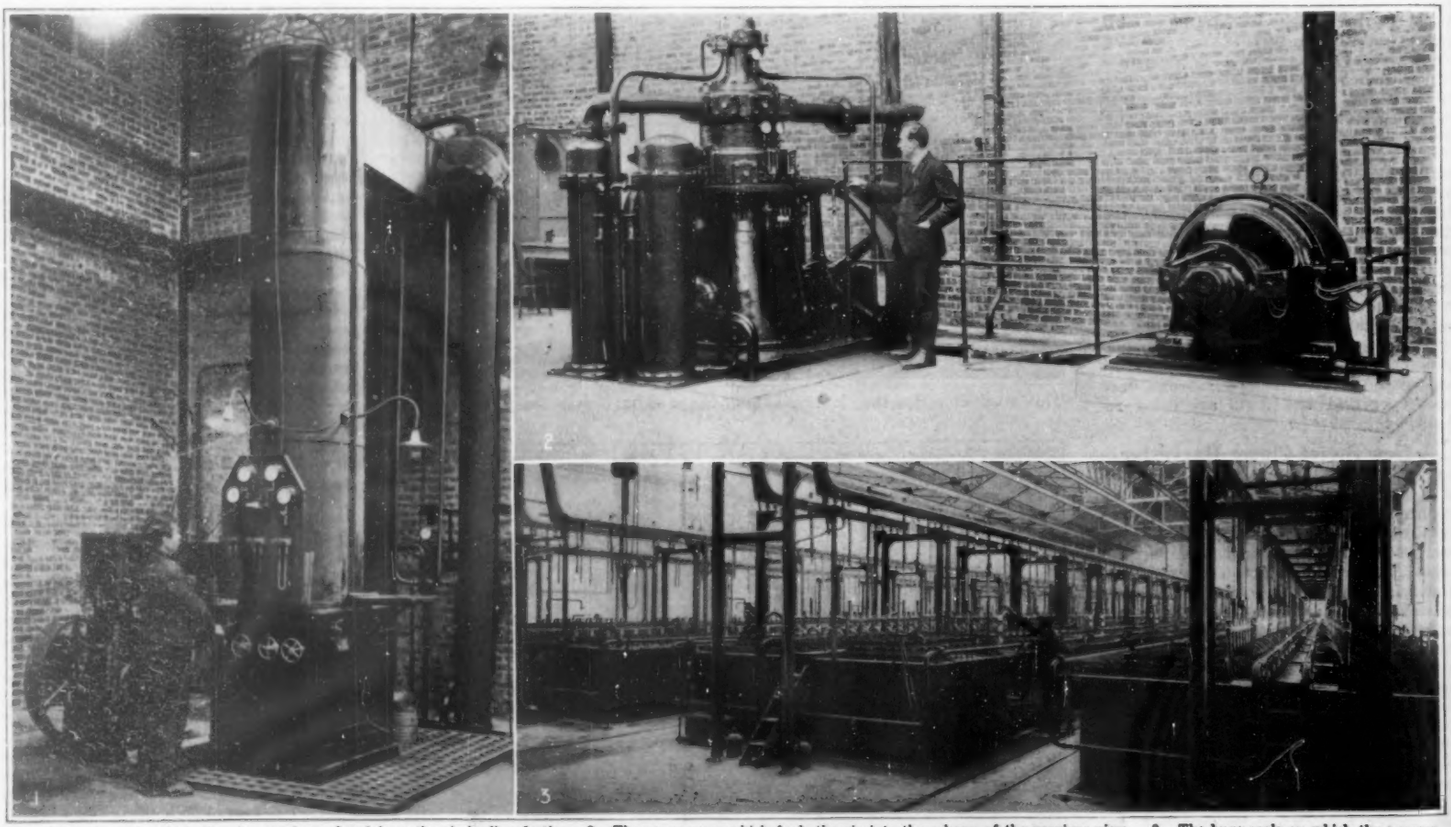
In order to avoid a possible explosion, the tube containing the catalyzer and in which the synthesis of ammonia is effected, is put in a concrete well outside the buildings. Each catalyzing tube is 2½ meters long, 2 centimeters thick and has an inside diameter of 0.018 meters. Once it is started, the reaction continues without any difficulties. What is remarkable, is that these enormous pressures can easily be handled. The apparatus does not allow the escape of any noxious vapors in the air of the room; the joints of the hypercompressor remain tight and tiny tubes suffice to hold considerable masses of gas. The liquefied ammonia is gathered in steel tubes and the ammoniacal dissolutions, more or less concentrated, are put in glass containers.

What distinguishes the Georges Claude method of synthetic manufacture of ammonia, from the process invented by the German Haber, is the incontestable superiority of its yield. With an equal volume, the Claude catalyzing tubes produce 25 times as much as the colossal installations at Oppau (near Ludvigshafen) and at Merseburg (near Halle) in which the Boche chemist carries on his manufacture.

The capital importance of this newborn industry can be seen at a glance. The production of synthetic ammonia by means of nitrogen from the inexhaustible air and electrolytic hydrogen assures to France in war times the possibility of manufacturing without limit the explosives necessary for her defence, and in peace time, allows her to obtain cheaply sulfate of ammonia, the fertilizer so necessary for the development of her agriculture.

Kaolin

BESIDES its most familiar use in pottery, kaolin finds application in the paper industry as a filler. This clay is obtained by washing kaolin in long troughs under conditions which permit that portion best suited for ceramics to float off, while the heavier particles, which go to the paper trade, sink to the bottom. About two parts of kaolin suitable for paper filler are obtained from three parts of raw material.



1. The column in which the nitrogen is produced from the air by liquefaction. 2. The compressor which feeds the air into the column of the previous view. 3. The huge scale on which the process may be carried out is indicated by the magnitude of these electrolytic separators that supply the hydrogen

The apparatus with which M. Claude obtains hydrogen and nitrogen for the manufacture of ammonia

1. Pile after treatment; reinforced with chicken wire and built out ten inches to its original size, protection is now absolute. 2. The dry sand-and-cement mixture is forced through a fine spray of water, gathering moisture for cementing at the point of contact. 3. The flat cars that supply ammunition for the cement gun. 4. Condition of a pile after four years' struggle with the limnoria—the same pile shown after treatment in the first view.

How piles are protected against the wood borer by use of the cement gun

The Wood Borer Takes the Count

HOW to protect piling, when driven in salt water, from the attacks of the teredo, limnoria and other wood borers has been a problem for years. The cement gun is the answer. It has been proven that by "shooting" a mixture of three parts sand to one part cement into the pile on all sides a covering completely impervious to water is obtained—one which does not break off, resists chemical action, and entirely prevents the entrance of all forms of animal life.

When the traction company undertook the survey of its electric road skirting the shores of Puget Sound between Bellingham and Mt. Vernon, Wash., it faced a two-horned dilemma in the first place. It was either an expensive rock cut along the face of the mountain or a four-mile trestle across the tide flats, a combat with earth and rock slides on land or the depredations of wood borers in the water. Terra firma was first chosen, but after a few weeks' work, during which time enough débris rolled down upon the railroad track below to give warnings of perpetual trouble, this plan was given up and the company "went to sea."

The trestle was driven in 1911. At the end of four years the attacks of limnoria had become so serious as to require drastic treatment and the erection of fortifications began. It might be mentioned that there is a difference between the limnoria and teredo, the two most destructive agents. The former feeds on the wood while the latter enters it only for the purpose of making a home. Limnoria completely destroy the pile, eating it out in a cone shape, while the teredo honeycomb it, leaving the shell intact. Limnoria are never found below the mud line, but usually stay some 18 inches above it, whereas the teredo is usually found higher up.

At first a short iron casing was placed around the base of the pile extending nine inches above and below mud line. This was used as a form and filled with cement, making a coating about one inch thick. The pile was then given a brush treatment with a one-to-one sand and cement mixture which covered all that portion below the high water line. The precautions were only partially successful, however, and the work of destruction continued.

By way of experiment, hydrated lime was in some cases used in the cement mixture, the idea being that it would pour inside the casing better; but the action of salt water very soon completely disintegrated the cement mixed in this way. Where lime was not used it stood up better, but was not water tight and pieces flaked off. Engineers then cast about for some method of forcing cement into the pile instead of pouring it around the outside. Enter the cement gun.

The gun itself however, is only a part of the equipment needed, two flat cars being required to accommodate the entire plant. One of them carries a large water-supply tank with a smaller 100-gallon pressure tank and an air compressor, while the other carries the cement mixer and raw materials. The cement gun proper, which is operated by a ground man underneath the trestle, is supplied by two lines of hose, one from the mixer and the other from the pressure tank. A dry mixture of three parts sand to one of cement is forced through one hose and water is forced through the other. The two streams join at the nozzle of the gun, where the solid particles are driven through a fine mist or spray and the moistened sand and cement penetrate the pile. The operator is able to control the supply of water with a hand lever. Under ordinary circumstances, the drier the mixture the better the results. The mixture is dashed against the piling with such force that when hardened it is impossible to make an indentation with a knife. All the voids are filled. Where piles were badly eaten away they were reinforced with chicken wire before treatment, and often built out to a thickness of from eight to twelve inches.

Experiment shows that the application of this treatment to partially destroyed piling does not strengthen it but merely affords protection. This fact was ascertained by a test made with two cedar sticks 13 inches in diameter by three feet long. One was left in its natural state and the other cut so as to resemble a pile attacked by limnoria and then built up with the cement gun.

The trestle where the cement gun was used contains approximately 5,700 piles, of which 5,200 were treated, the others being above water line. Costs vary according to local conditions and the amount of damage to be repaired. In the case here discussed, it was possible only to work at low tide and it was frequently necessary to clear the track for regular traffic, which delayed the work and added to its cost. The best estimates available show an expenditure of from 30 to 35 cents per lineal foot for the treatment.

The next step will be to treat the piles before they are driven, and laboratory tests indicate that this can be readily accomplished. The piles will be placed on rollers, thoroughly wet, and then sprayed to get a quarter-inch to a half-inch coating. When so treated the cement can only be flaked off with a sledge hammer and cold chisel, and the cost will of course be much less.

Floating into place the 208-foot span in the new bridge at Washington

A New Idea in Placing a Big Span

THE high tide of turbulent waters, so frequently destructive, is occasionally an ally in accomplishing an engineering feat. A notable instance is the recent undertaking in Washington, D. C., in the placing of the initial steel span for a new bridge over the Potomac River.

The span, 208 feet long and weighing approximately 200 tons, was built on a float and lifted into place by a swelling morning tide. The superfluous structure was displaced at low tide during the afternoon of the same day.

The magnificent viaduct displaces the historic, antiquated Georgetown bridge. The completed structure rears itself 72 feet above mean water level, which is the height of the clearance arch. The roadway is 84 feet above mean water level. The solid footings which formed the basis for the floats, located on the piers, will serve as the resting place for the finished viaduct.

The Heavens in February, 1921

The Diameter of Betelgeuse—How It Was Measured and What It Means

By Prof. Henry Norris Russell, Ph.D.

PUBLIC attention has been widely and deservedly attracted during the past month to a notable achievement of observational astronomy—no less an advance than the actual measurement of the diameter of a fixed star.

From the days of the first astrologers till now, the stars have shown themselves to us merely as points of light—more resembling the "mathematical point" than do any other natural objects. To the naked eye they are dots on the expanse of heaven; and viewed with our greatest telescopes they remain dots still—dazzlingly bright, perhaps, but without perceptible size. With a high magnifying power, it is true, all stars appear as minute disks; but the size of these disks depends, not on the star, but on the telescope. They are mere optical effects, inevitably produced by the influence, upon the waves of light, of the circular aperture through which the light enters the telescope, and forming, as it were, an image of this aperture, and not of anything in the heavens above.

The greater the aperture of the telescope the smaller will be this "diffraction pattern"; but even with the largest instruments, it remains of such a size as to conceal from us those fine details which often we would most desire to observe—such as the existence of very close double stars, and, in particular, the actual disks of the stars themselves. But Professor Michelson, by a brilliant application of the interferometer, has added the solution of this problem to the large list of scientific advances which this apparatus has permitted. A fuller account of this matter is given in the SCIENTIFIC AMERICAN MONTHLY for February, by the present writer, and will be found of interest to those who wish to understand the process in greater detail than is here given.

The Michelson Apparatus

The principle of the apparatus is simple enough. A diaphragm is placed in front of the telescope, so that light is admitted to it only through two parallel slits, which may be at any distance apart, up to the full diameter of the objective. The beams of light which enter these slits are brought to a focus at the same point, where the ordinary star-image would be. At the center of this image the two beams, which have traversed exactly the same distance in coming from the two slits, arrive in such fashion that the two sets of light waves reinforce one another. But at a short distance on either side a point can be found where the light from one slit arrives sooner than that from the other, in such a way that the light waves from the two slits are out of step with one another, and "interfere" so as practically to destroy one another. At a point farther out, one stream of light has gained a whole wave length on the other, and reinforcement again takes place; and this sequence is repeated again and again, so that the neighborhood of the focal image is occupied by a series of fine bright and dark bands or "fringes," parallel to the length of the slits.

If there is a second star close to the first, the light will form another independent system of fringes, superposed on the first set; and if the bright bands of the one system fall on the dark bands of the other, the general effect will be to obliterate both—completely if the two stars are equally bright, partially if they are unequal.

The importance of this lies in the fact that these fringes are very narrow—less than half as wide as the round star-images formed when the aperture of the telescope is entirely clear. If these two stars are so close together that their ordinary telescopic images overlap, and are superposed, the two sets of fringes may nevertheless be displaced relatively to one another by an amount great enough to cause a disappearance, or at least a serious loss, of "visibility," and in this way the duplicity of the star may be revealed, as was done a year ago with great success in the case of Capella.

The new apparatus does not indefinitely increase the "resolving power" of the telescope, but it rather more than doubles it. What is even more important, it is found by observation—much to the astonishment of experienced astronomers—that the "bad seeing" due to disturbances in the earth's atmosphere, which does such very serious damage to the definition of the images formed by great instruments, affects the interferometer to a very much smaller degree, so that, on poor nights when the telescopic images seen directly are diffused and trembling, and all the fine details are lost, the fringes are still easily visible, and can be well observed.

Measuring Star Diameters

The interferometer can be used to measure the diameter of a small luminous disk, as well as the separation of a close double star. In this latter case the two sides of the disk play the same part that the two isolated stars did before, and, for a proper separation of the slits, the fringe systems formed by the light from the opposite sides of the star-disk will be superposed and obliterate one another.

It requires a much larger instrument to measure the diameter of a disk than the distance of a pair of double stars whose separation is equal to the disk's diameter; for it is the distance between the middle points (so to speak) of the two semicircular halves of the disk, and not the distance between their remotest outer edges, that the instrument really measures. But even so, the interferometer once more, in this case, greatly increases the power of the telescope to which it is applied. A further gain is possible, for, as Michleson has done at Mount Wilson, a long beam with a carefully planed flat surface may be placed across the outer end of the telescope, at right angles. Two mirrors, which can be set along this beam at any desired distance from the center, receive the star's light and reflect it inward to a second fixed pair of mirrors, which send it down to the two slits already described, and so into the telescope. With this arrangement, the effective distance between the slits becomes equal to the distance which separates the outer mirrors, and the gain in resolving power is proportionate.

The apparatus which has just been put into use at Mount Wilson, as an attachment to the 100-inch telescope, permits of a maximum separation of twenty feet between the mirrors. This gives a resolving power equal to that which would be obtained by direct vision with a telescope 40 feet in diameter, so that the instrument is incomparably more powerful than anything that has ever before been pointed at the stars.

With the mirrors at their widest separation, white stars—even the brightest, like Sirius and Procyon—still show sharp fringes, which indicate that the apparent diameters of the real disks of these stars are too small to measure, even with the great advance in instrumental power. But with bright red stars the case is different. Observations on Alpha Orionis (Betelgeuse) showed a marked decrease in the visibility of the fringes when the mirrors were eight feet apart; and when the distance was increased to ten feet the fringes vanished. From this it may be calculated that the angular diameter of the star is about 0.045 second of arc. Further measure, giving a more precise determination, will probably soon be made. Meanwhile it is well to consider what this announcement means.

The Case of Betelgeuse

One twenty-second part of a second of arc is a small quantity indeed. It corresponds to the apparent angular diameter of a disk (or of course of a sphere) one foot in diameter and 850 miles distant. That it should be possible to measure anything so small is in itself amazing.

But when we come to turn this angular measure into miles, the results are even more startling, and this time by their greatness. The parallax and distance of Betelgeuse are not yet known with any great degree of precision; for the star is very remote, and its parallax so small that even the best measures are affected by a large percentage of error. From the existing material (which will doubtless be supplemented by additional observations within the next few years) it appears that the parallax is probably about 0.012 or 0.015 seconds, and the star's distance some 200 or 250 light-years. But the parallax measures the angle that would be subtended by the line joining earth and sun, if removed to the star's distance. It follows that the diameter of Betelgeuse is probably fully three times as great as the earth's distance from the sun—in round numbers, about 300,000,000 miles, fully as big as the whole orbit of Mars, and much bigger than that of the earth. This conclusion has, very naturally, produced a great impression upon the whole educated public.

The professional astronomer was perhaps better prepared for the announcement. It has long been realized that those stars which are very luminous and yet very red, and which presumably give out relatively little light per square mile of surface, must be very large. Various astronomers, among them Eddington in England and the present writer in this country, have called attention to this, and even gone so far as to publish approximate predictions of the diameters of such stars—predictions which, in the writer's case, appear to be about two-thirds of the actual value.

The direct confirmation of the existence of these giant stars is however of the utmost interest and importance, and will be welcomed more enthusiastically by none than by those who find their own theoretical studies confirmed—and superseded—by these observations.

The Heavens

The southeastern and southwestern heavens now vie with one another, the latter having the preponderance of bright stars, but the former boasting the presence of Jupiter and Saturn, which partially at least restore the balance. Orion is well up in the southwest, with the giant Betelgeuse uppermost, the white stars of the belt below, and the brilliant Rigel lower still. Aldebaran is on the right, with the Pleiades beyond, and Sirius on the left. Procyon is above Sirius, and Castor and Pollux above Orion and almost overhead.

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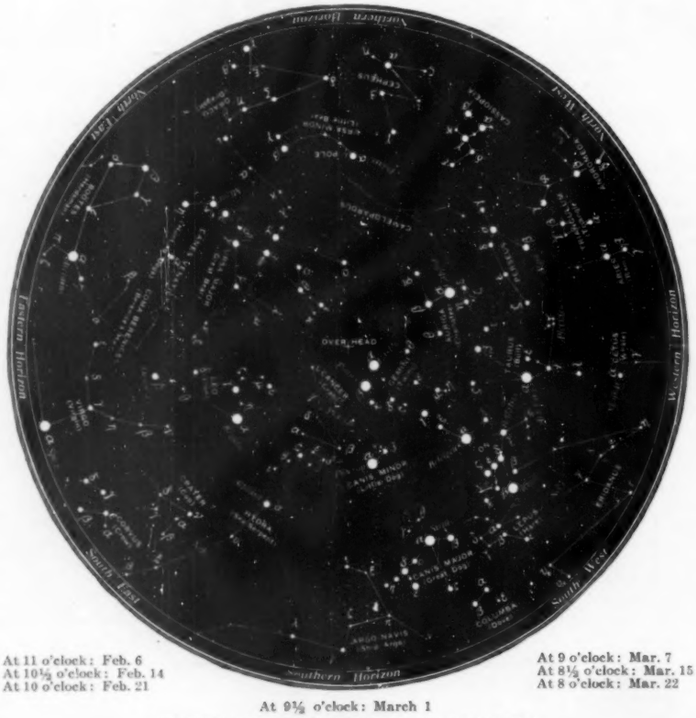
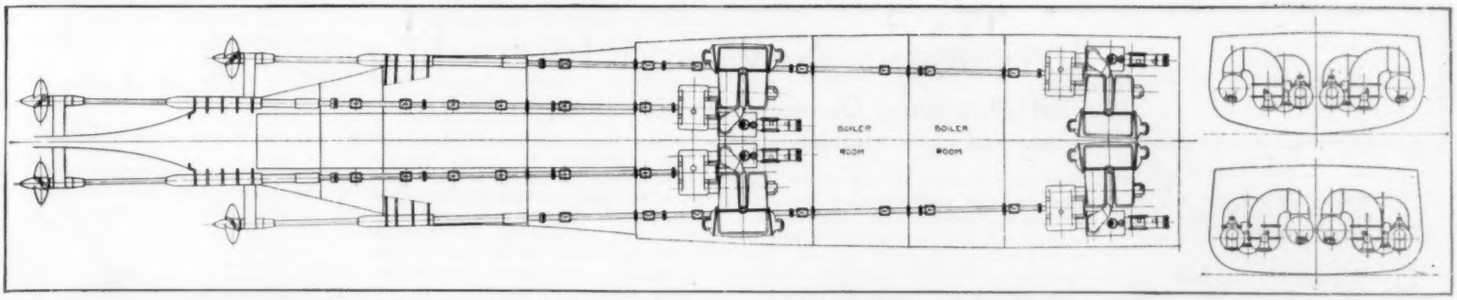


At 11 o'clock: Feb. 6
At 10½ o'clock: Feb. 14
At 10 o'clock: Feb. 21

At 9 o'clock: Mar. 7
At 8½ o'clock: Mar. 15
At 8 o'clock: Mar. 22

At 9½ o'clock: March 1

NIGHT SKY: FEBRUARY AND MARCH



Plan and cross-sections through the engine rooms of the new 7,500-ton, 35-knot U. S. Scouts

The Motive Power of the New 35-Knot Scout Cruiser

THE new U. S. light cruisers now under construction, an illustrated description of which was published in our issue of January 15, 1921, will be the most effective scouting vessels ever built by any nation. They will be swift enough to outrun anything afloat; large enough to keep their speed in heavy seas; roomy enough to rush detachments of marines to "trouble spots"; and powerful enough to overwhelm destroyers and other light craft.

Interesting as these vessels are as naval units, they are perhaps even more so from the standpoint of steam engineering, since each is to be driven by geared turbines having a total capacity of 90,000 horsepower. Never before has so large an amount of power been installed in so small a space, and in consequence the performance of these vessels will be carefully followed by engineers and naval men all over the world.

Each ship has four 22,500 horsepower cross-compound Westinghouse turbines, and each turbine is geared to a propeller. The turbines for the two center propellers are placed together in an engine room located well aft, and the turbines for the wing propellers are placed in a second engine room farther forward, with the boiler rooms between the two engine rooms.

Each turbine consists of a high-pressure and a low-pressure element which drive the propeller through a common gear. The high-pressure element consists of two rows of impulse blading followed by reaction blading. A special belt of this reaction blading is used only when running at low speeds and is bypassed for operation at higher speeds. The low-pressure element, which normally receives steam from the high-pressure element and discharges it into the condenser, has reaction blading only. Both elements are rated at 11,250 horsepower each, and either can be used independently in case the other is out of service for any reason.

An astern turbine, consisting of two rows of impulse blading, is incorporated in each low-pressure element. When supplied with the same amount of steam as for full ahead operation, the astern turbines can develop 30 per cent of the full ahead power and can drive the ship at about 20 knots.

The reduction gears are of the Westinghouse floating-frame type. Each has two pinions, one for the high-pressure and one for the low-pressure rotors, and a single gear wheel connected to the propeller shaft. The speed reduction ratio is about 7 to 1 and is effected in a single step.

The main turbines can propel the ship at speeds ranging from 12 to 35 knots, but as only a relatively small amount of power is needed for low speeds, small auxiliary turbines are used for cruising purposes. There are four of these cruising turbines per ship and each consists of a single-row impulse wheel and can develop 420 shaft horsepower at 6,000 revolutions per minute. Each cruising turbine is mounted on an extension of the case of a main high-pressure element and can be coupled to the high-pressure rotor through a gear giving a speed reduction of about 6 to 1. The mechanical line-up is therefore: cruising turbine, cruising gear, coupling, main high-pressure rotor, main low-pressure rotor, main gear, propeller shaft. The steam first passes through the impulse blades of the cruising turbine, then through the reaction blades of the cruising belt of the main high-pressure element, then through the remaining reaction blading of both elements, and finally into the condenser. With this arrangement a maximum power of 1,000 horsepower can be obtained from each of the four turbines. The cruising speeds range from 12 to 15 knots with excellent steam economy over the entire range.

The coupling that connects the cruising turbine with the rotor of the main turbine is operated by means of a hand lever. To connect a cruising turbine when the main turbine is in operation, the former is brought up to speed and the latter slowed down until a synchronizing device indicates that the two are operating at the same speed, when the connection can be made with safety.

Special care is taken to prevent the cruising turbines from over-speeding either when operating under their own power or when accidentally left connected to the main turbines and driven by them. A fly-ball governor controls the throttle to each cruising turbine and also, through a relay, the governor valve of the main turbine. If the cruising turbine operates at 10 per cent over speed, this governor cuts off the steam to both turbines. If this governor should fail to operate at 12 per cent over speed, an emergency stop cuts off the steam to the cruising turbine, and disconnects the coupling.

Water Injection in Gasoline Engines

THE practice of injecting water in conjunction with the fuel is quite common in kerosene engines, the object being to keep down the cylinder temperature under conditions of heavy loading and prevent preignition. In fact, it seems very difficult to operate an Otto cycle kerosene engine and get satisfactory results without water injection. There also has been considerable experimentation with water injection (or induction) in gasoline engines, by makers of fuel conditioners and their customers, who believe that the injection of water will lessen or eliminate the formation of carbon deposit and increase the fuel economy.

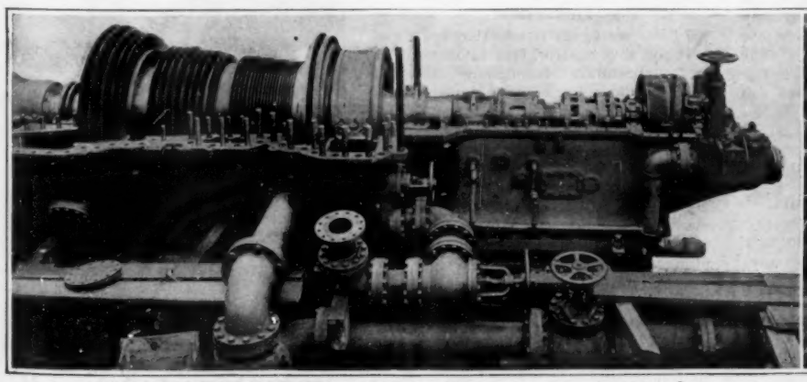
In the development of aircraft engines, the suggestion was made that if water injection had these effects it should be beneficial in aircraft work. The problem was assigned by the National Advisory Committee for Aeronautics to the Bureau of Sandards, and an extended investigation was made. The tests were carried out on a Class B military truck engine, and also on a Rutenber 6-cylinder, 3 x 5 in. engine, which operated at high jacket temperature. Although the investigation was made at the instigation of the Aircraft Department, the tests were conducted on a truck and an automobile engine, but the results, of course, are of general application.

The results arrived at have been summarized by the experts of the Bureau of Standards somewhat as follows: No appreciable effect is produced upon the power, fuel economy and general operation of a gasoline engine by the injection of water into the cylinders at rates varying from 0.03 to 0.44 lb. per brake horsepower-hour. When water is injected at a higher rate than 0.44 lb. per brake horsepower-hour there is an appreciable decrease in the power output, fuel economy and smoothness of operation. It is quite probable that in a badly carbonized engine, or an engine of defective design, in which there are hot spots that cause preignition, the injection of the water results in an increase of power. In an engine operating at high waterjacket temperature the injection of water in amounts between 2 and 8 lb. per hour produce a softening and slight reduction of carbon, this reduction not exceeding 25 per cent and being most noticeable in the piston heads and valves. However, water injection at the maximum rate also causes a considerable reduction of power.

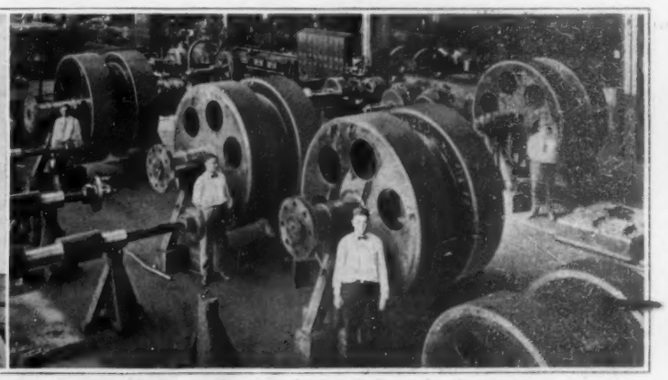
Photographs That Educate While They Entertain

A LIVELY bathing scene in which the pool is a dewdrop and the bathers are creatures too small for the naked eye is shown in one of the recent motion-picture releases by the United States Department of Agriculture. The new film, known as "A Plant Disease and How It Spreads," was photographed under the supervision of scientists in the Bureau of Plant Industry. The pictures, most of which were taken through a microscope, deal with the organisms that cause rhubarb blight and result in heavy loss in truck-farming sections. Field scenes also are included. Symptoms showing the existence of the blight, the extent of damage wrought, and methods of eradication are depicted in the film, which will be distributed through department channels.

The new "movie" is one of the few that have been photographed largely through a microscope, and because of that fact is expected to attract added attention. It is designed for both scientific and popular use, and is expected to be much in demand among educational institutions. The department has more than 500 films in circulation, showing over 115 subjects. They have proved of marked value in extending the work of the department.



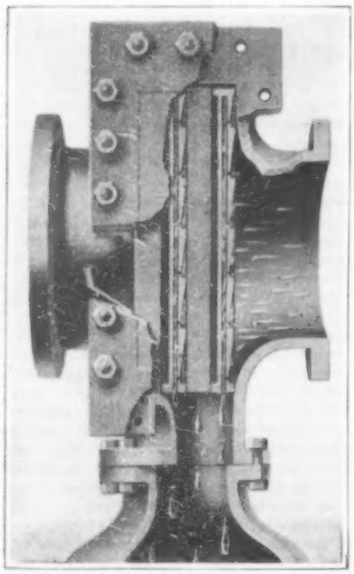
High-pressure turbine and cruising turbine, upper covers removed



Pinions and gear wheels of the reduction gear

Inventions New and Interesting

A Department Devoted to Pioneer Work in the Arts



Broken away view of a device which separates oil from exhaust steam

Separating Oil from Exhaust Steam

WHILE the oil-separating device shown in the above illustration has been in use for some years past, it continues to hold the field because of its efficient work. The features of the device, which is shown partly broken away, are as follows:

The shell and baffle plates are of cast iron. These multiple baffle plates are of special staggered grid construction and are so designed as to ensure the removal of all oil from the exhaust steam before it leaves the separator. The oil, after being deposited on the saw-tooth grids, enters a duct inside of the grid bars and flows through this duct to the large receiver reservoir at the bottom. This feature prevents steam from picking up the oil again after it has been deposited on the baffle plate.

The separator is said to fulfil one of the most important requirements of an efficient oil separator. It is apparent that if an oil separator is efficient, the separation cannot be accomplished without the baffle plate surfaces becoming gummed with oil and grease, and also that this coating reduces the separating efficiency. It is, therefore, essential that an oil separator be so constructed as to be easily cleaned. The baffle plates in this separator are removable through an opening provided and may be taken out and cleaned in a lye solution and returned to the separator ready for another period of service.

This cover slips over the milk bottle, keeps milk clean and facilitates pouring

A Cover for the Milk Bottle

A RECENTLY patented milk bottle cap, made of aluminum, is a device that has two improvements. First, it has a hole in the top, opposite to which is a lip, so that milk can be readily poured into a glass or cup. When not wanted for pouring, a tight cover slips back over the hole out of which the milk has been poured. Much time can be saved with this cover, for it is not necessary to remove the cap to get at the milk. Again, the milk in such a bottle is not exposed to dust or the air.

A Circular Saw-of-All-Work

WE illustrate herewith a universal circular saw of interesting design. It will be seen that it is mounted on a carriage that makes it possible to bring it to the work in any conceivable position. The photographer has tried to indicate the extraordinary range of applicability of the saw by showing it at work on a rather unusual job of cutting off a barrel. This is but a suggestion of the uses to which this ingenious device can be put. It is operated electrically, as indicated by the presence of wire and motor in the picture; the consumption of current is said to be extremely moderate.

A Better Hood for the Electric Welder

ONE of those simple improvements designed to facilitate a given task takes the form of a new helmet for men engaged in electric welding operations. The body of the helmet is made of chrome leather, which has been treated so as to make it impervious to water and the injurious rays which accompany welding operations. The helmet is provided with a window of chemically prepared glass which protects the eyes from the ultra-violet rays.

Now the main improvement which this mask or helmet represents over the usual type is in the mounting of the window, which is such as to permit it to be raised with the left hand of the operator as shown in our illustration. In this manner the operator can view his work without the intervening dark screen, yet let the screen fall back in place when ready to go ahead with further welding operations. Obviously, this helmet saves much time, for ordinarily a welder would remove his helmet in order better to see the finer details of his work.

Copyright, Keystone View Co.

A twist of the left hand lifts the protective screen out of the way in this new welding helmet

A Partnership of the Fork and Knife

A LOGICAL development of the great war is the one-hand knife and fork utensil which is shown in the accompanying illustration. With this combination knife and fork a person with but one hand can cut meat and feed himself surprisingly well. The knife is in the form of a steel blade with a curved cutting edge, and with a number of prongs at the end to serve as the fork. For cutting the meat the curved edge is placed on the meat and the blade is moved back and forth. Of course, the cutting edge must be keen in order to work satisfactorily.

A combination knife and fork for the one-hand man, shown in the act of cutting

Crayons That Blend

THE problem of perfecting wax crayons so that their colors will blend while being applied has been solved by Prof. Katherine Lewers of the University of Nevada by the use of a solvent, such as kerosene, applied as a wash to the back of the paper. Since this wash evaporates slowly, rewetting is unnecessary for an hour or more.

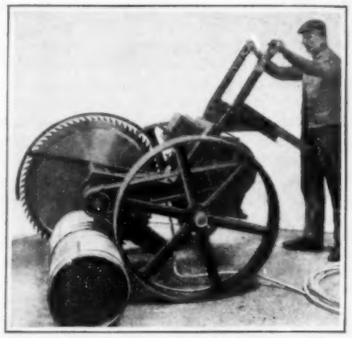
Thus, by the mere process of overlaying and rubbing in, a few crayons of standard colors will be sufficient to obtain any delicate shade.

Whether wax painting shall regain its original prestige as an art medium, its use in the schools, where a dry medium is much to be preferred to a wet and where numberless changes must be made, is of first importance in teaching color appreciation.

Briqueting Outfits for the Household

NEED we again repeat that coal, and for that matter fuel in general, is at a premium throughout Europe? Hence these columns have depicted and described almost no end of fuel-saving devices during the past few years, and we have one more device to add to our published collection, in the form of a household briqueting outfit.

This briqueting outfit is a French device which is meeting with considerable favor. It consists of a stand, a simple plunger, and a set of simple molds. The material to be briqueted is placed in the mold, and then, with several sharp tamps with the plunger, a briquet is formed. The briquets may be made in the form of balls or disks, according to conditions.



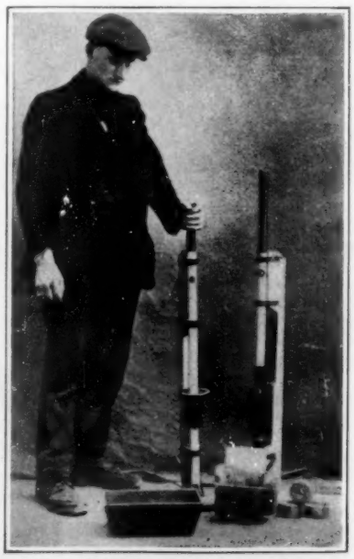
The saw for a thousand jobs, and one that goes to its jobs

Recent Patent Decisions

Joint Inventions.—This is an appeal from an award of priority to appellees Hope & Lambert for an invention relating to an apparatus for drying wood veneer, consisting of a rectangular housing for the material to be dried.

A single count of the issue is set forth as follows: "A dry kiln comprising a rectangular shaped housing, a radiator located in one end of said housing forming an end way thereof and provided with openings through which air may be drawn, the opposite end of said housing closed by an end wall, and an exhaust fan connecting with the interior of said housing through said wall."

It appears that Hope and Lambert filed a joint application November 29, 1915, and thereafter Lambert filed an individual application on May 8, 1916, which inadvertently went to patent June 5, 1917, while the joint application was copending. The decision of the lower court is affirmed, and the following point of law adduced: Where a joint application for a patent was filed, and later one of the applicants filed an individual application which inadvertently went to patent while the joint application was copending, the individual applicant gained nothing by the issue of the patent to him.—*Lambert v. Hope et al. U. S. C. C. A. of D. C.*



A few sharp tamps with the plunger produces briquets for the household

Stopping the Chimney Thief

(*Continued from page 101*)

a definite weight of fuel will require a definite weight of oxygen supplied by the air. Each atom of carbon will unite with two atoms of oxygen to form carbon dioxide (CO_2) and each two atoms of hydrogen will require one atom of oxygen to form water vapor (H_2O). Varying proportions of carbon and hydrogen in the fuel will call for different proportions of oxygen, hence the exact amount of air required cannot be specified until the chemical composition of the fuel is known. Few fuels however require over sixteen pounds of air for every pound of fuel burned, and some need no more than 10 pounds of air per pound of fuel. These proportions provide a slight excess of air over the amount indicated by chemical theory. Whatever the ideal proportion of air to fuel may be, it is important to keep as close to it as possible, for reasons that will be explained shortly. As there is no simple way of metering the fuel and air while they are being united chemically it may appear that this problem presents extreme difficulties. Such, however, is not the case for continuous examination of the flue gases furnishes a means of keeping tabs on the proportioning of air and fuel.

The problem of efficient combustion then is not so much one of knowing how to shovel coal or operate oil valves but is primarily one of always regulating both fuel and air supply simultaneously so that the ratio of air to fuel will always be uniform. After the correct ratio is established, the fuel may burn fast or slow according to the demands for steam but by modern means of control can be made always to combine in whatever ratio is found to represent best economy.

It is not generally realized that more air than any other substance is used up in a power plant—by weight about 16 tons of air and by volume over 400,000 cubic feet of air to every ton of coal. It is not easy to realize just what these figures mean, so they will be expressed in another way. If this air flowed into the furnace through a square conduit 1 foot high and 1 foot wide the conduit would have to be over 75 miles long in order to contain enough air to burn just one ton of coal. This shows quite impressively the importance of the air supply. Expressed differently, all the air, from earth to sky, above a square inch of the earth's surface weighs 14.7 pounds, hence would be scarcely sufficient to burn a pound of coal.

If less air than this is supplied then some of the fuel will pass up the chimney as unburnt gases or smoke. That of course also represents a loss. It is seldom however that too little air is supplied, the reverse condition being almost invariably the case. The greater the excess air the more heat will escape up the chimney because all air whose oxygen does not combine chemically with the fuel absorbs heat from the fire and carries it away through the stack without allowing it to do useful work such as heating water or making steam. It makes little difference whether this excess air leaks in above the fire through the boiler sides or ends, or enters through the fire or ash-pit doors. If the correct air-fuel ratio is exceeded, a needless loss of fuel is bound to result, just as in the example of the grate fire previously mentioned.

Fortunately we have in the flue gases an excellent source of information as to just what the excess of air amounts to. A given volume of oxygen unites with carbon to form exactly the same volume of carbon dioxide. For example, one cubic foot of oxygen will form one cubic foot of carbon dioxide as it combines with the carbon in the fuel. Air contains 21 per cent by volume of oxygen. If the flue gases contained 21 per cent of carbon dioxide we would know that all the oxygen had been used to burn up carbon, but that would represent perfection which is

(*Continued on page 117*)

Recently Patented Inventions

Brief Descriptions of Recently Patented Mechanical and Electrical Devices, Tools, Farm Implements, Etc.

Of General Interest

BOTTLE CAP.—E. G. BAUM, 21 W. Central St., Natick, Mass. This invention contemplates the production of a thoroughly sanitary leak-proof closure applicable to any standard milk bottle. An important feature of the closure is the multiplicity of points at which it seals itself to the mouth when applied, thereby insuring the consumer of a germ-proof package.

RINSE TUB.—P. O. VANATTER, c/o V of Ga. Athens, Ga. An object of this invention is to provide a tub which is divided into compartments and which has rotary mounting so that each of the compartments can be brought into convenient operative position by simply turning the tub. A further object is to provide each compartment with a drain pipe.

DISPLAY FIXTURE.—L. SHOGRAN, 850 Grace St., Chicago, Ill. Among the objects of the invention is to provide a display fixture adapted to support articles of varying sizes. A further object is to provide a fixture which can be instantly adjusted and is adapted to firmly hold ordinary supporting plates of various sizes without altering the plates in any way, or boring holes therethrough.

STATIONERY.—A. CALCANO, Caracas, Venezuela. This invention has for its object to provide a combined envelop and inclosure, formed from a single blank having lines of partial separation and lines of adhesive for permitting the sheet to be folded into a letter and an envelop for the letter. The sheet is so arranged that the letter may be written by hand or on a typewriter, as desired.

STRAW DISPENSER.—C. H. SHELTON, 25 Peachtree St., Atlanta, Ga. The invention relates to a device for the dispensing of drinking straws at soda fountains. The purpose is to provide such a device which automatically delivers the straws singly to a convenient position for withdrawal, the remaining straws being housed and protected against dust or other foreign matter accumulating thereon.

EGG CARRIER.—R. McN. and H. R. WILLIS, 907 W. Main St., Chanute, Kans. The object of this invention is to provide a carrier of the character specified formed of pasteboard or like suitable material wherein the blank for the complete carrier may be stamped from a sheet of pasteboard or the like, and creased on lines which will permit it to be folded into a closed carton, having individual egg cells.

PROCESS FOR THE AUTOMATIC REMOVAL OF COPPER FROM ORDNANCE.—A. E. A. DAGORY, Bois Colombes, Seine, 8 Ave Robert Bain, France. This invention relates to a process for automatically freeing guns of all calibers from the copper which is deposited during the firing in the interior of the bore. The operation consists of removing the copper by applying to the shell a compound of tin with lead, said compound to be projected along the walls of the bore and brought into contact with the copper deposited on said walls.

SLED.—W. SCHUTTE, Haddam, Conn. An object of the invention is to provide a sled of the self-propelling type which may be propelled and steered by the operator at the same time, with a hand operating propelling means and a foot operated steering means. The device is simple and durable in the construction, combination and arrangement of its parts.

LETTER AND PACKAGE TYING DEVICE.—M. R. HUGGINS, Bethel, Ohio. The invention has for its object to provide a construction wherein the parts are reduced to a minimum and wherein after the first operation of tying it will remain straight and in proper position for all other additional operations. A further object is to provide a device which will securely hold the letters bunched and yet permit one or more to be withdrawn without completely untying.

WINDOW CLEANER.—L. SONDEREGGER, 413 E. 153rd St., Bronx, N. Y. The object of the invention is to provide a window cleaner more especially designed to permit the user to clean the outer faces of the upper and lower window sashes. Another object is to permit of readily placing the cleaner in position on the window and manipulating the cleaner without requiring undue physical exertion.

SAFETY DESK.—M. H. LYTTLE, 374 W. 80th Place, Chicago, Ill. The invention has for its object to provide a safety desk having a drop head which can be instantly dropped into a strong box which is automatically closed and locked, thus safeguarding articles resting upon the drop head from loss by theft, fire, or other causes. A further object is to provide a device that can be operated by a person seated at or standing by the desk, without his action being observed.

MOVING PICTURE CAMERA.—S. M. LAWHUN, address J. L. Perlman, 1893 Vyse Ave., Bronx, N. Y. The object of the invention is to provide a moving picture camera arranged to permit adjustment of the shutter opening to produce dissolving or double exposure, or trick work effects and for taking pictures under different conditions of light intensity of different rates of motion of the objects, the shutter being composed of adjustable sections to vary the exposure opening.

POLISHING COMPOSITION.—J. F. LINANE, 333 Micheltorena St., Santa Barbara, Cal. The invention has reference more particularly to a composition especially adapted for the cleaning and polishing of hard wood and metallic surfaces. The object is to provide a composition which will be cheap to manufacture and yet will give a brilliant luster. The composition consists of the following ingredients: mineral oil, oil of soy-bean, turpentine, gasoline and tripoli.

ONE-PIECE SLIPPER.—M. J. HOLLEBECK, 29 Orchard St., Gloversville, N. Y. Among the objects of the invention is to provide a one-piece slipper cut from suitable material, which may be designed over the human foot, the same as a surgical shoe, forming a perfect fit for the instep and at the side of the arch, leaving no seam at the heel which would cause irritation or discomfort.

SHAVING BRUSH.—L. TOBIAS, 717 Jackson Ave., Bronx, N. Y. The invention relates to a shaving brush equipped with the ordinary bristles for forming and distributing lather and also provided with means for rubbing the lather into the face to soften the beard, the parts being so constructed and arranged as to permit either the bristles or the rubbing device to be exposed for use at the end of a suitable handle, the brush is sliably mounted and may be entirely enclosed within the handle.

GLOVE.—H. I. SEELY, 450 Penn Ave., Waverly, N. Y. The invention relates to heavy gloves for workmen, particularly engineers and firemen. The glove is made of leather or similar material, liable to withstand great strain. The invention provides a method of joining the palm and thumb blanks of the glove by a lace in such manner that it will withstand any reasonable amount of wear, and will be practically heat, fire, acid and waterproof.

Machines and Mechanical Devices

MACHINE FOR MAKING HAT LININGS.—R. BELL, 27 Bond St., New York, c/o N. Y. Hat Lining Co. The invention relates to machinery for producing hat linings and has for an object to provide a construction associated with an ordinary sewing machine whereby a lining member may be quickly and accurately formed. Another object is to provide an attachment which may be easily manipulated for cutting strips of cloth into certain lengths after passing through the sewing machine and then cutting draw strings of a different length.

MOTOR TREADMILL.—R. D. GEORGE, 4341 Tracy Ave., Kansas City, Mo. The invention relates generally to power apparatus, and more particularly to apparatus for the convenient application of power from the rear wheels of automobiles, motor trucks, and the like, for external or distant application, the object being to provide a comparatively simple apparatus which may be readily associated in operative relation to the motor vehicle.

MECHANICAL MOVEMENT.—G. MULLER, 103 Schley St., Glendale, L. I. The object of the invention is to provide a rack and pinion feed mechanism more especially designed for converting reciprocating movement into intermittent rotary movements in an exceedingly simple manner. Another object is to insure proper transmission of the power without danger of injury to the working parts, at the same time reducing wear and tear to a minimum.

THREAD TENSION GAGE.—J. H. MESSINGER and A. E. TETU, Central Registry, Militia Department, Ottawa, Ontario, Canada. This invention relates to devices for indicating the tension of sewing machine threads and has for an object to provide a construction which will operate while the sewing machine is standing still, in order to allow a proper adjustment of the upper and lower threads, so that the device may be varied until the threads have the same tension, the variation being shown automatically on the gage.

MECHANICAL MOVEMENT.—F. CLARK, 15 Bedwell Ave., Jersey City, N. J. The invention relates more particularly to a mechanism especially adapted for the conversion of reciprocating motion into oscillating motion. The primary object is to provide a device operated by one of the elevators of a type-setting machine to indicate certain conditions in the work being set up by the machine, the device may be readily attached to machines of this type as commonly constructed.

Pertaining to Vehicles

AUTOMOBILE SEAT.—G. TASMAN, c/o Tower St., Forest Hills, Boston, Mass. An object of the invention is to provide a seat construction in which there is substantially no relative movement between the seat and the back thereof, there being provided a means for yieldingly supporting said seat, and another means to permit the yielding support to become effective, but to prevent the seat from tilting from its normal position.

VEHICLE.—A. H. PELTER, Box 286, Bristol, Tenn. The invention has for its object to provide a toy vehicle of the three-wheel type, having laterally spaced driving wheels at one end and the steering wheel at the other, and a body to which the wheels are connected, and having a seat which may be quickly adjusted to permit children of different ages and physical development to ride in the vehicle comfortably.

FENDER FOR MOTOR VEHICLES AND THE LIKE.—F. V. GUERRA, 100 Luyano, Habana, Cuba. The invention refers more particularly to a fender which may be conveniently used on motor vehicles without presenting an unsightly or cumbersome structure on the front of the vehicle, the platform being so constructed that it will normally assume an inactive position in the rear of a collision buffer but capable of being automatically brought into use by the impact of person.

ENDLESS TRACK FOR FACILITATING THE PROGRESSION OF AUTOMOBILE VEHICLES ON HILLY GROUND.—E. RIMAILHO, 12 Rue de la Rochefoucald, Paris, France. This invention relates to an endless track-shoe for connection with self-propelled vehicles, of the heavy type, to facilitate their travel upon uneven or hilly ground. When the shoe is positively driven it also serves as propelling means for the vehicle.

MEANS FOR EFFECTING TEMPORARY REPAIRS TO BROKEN AXLES OF MOTOR CARS.—E. J. DOVE, 190 St. John's St., Clerkenwell, London, E.C.1, England. This invention has for its object to provide temporary means whereby the driving axle of a Ford car, when broken at a point on either side of the differential gear, may be easily and quickly repaired either to permit the car to be towed on its own wheels, or driven away by its own power.

RADIATOR CAP LOCK.—T. HILL, 1135 Park Ave., New York, N. Y. The invention relates to closures for the filling opening of motor vehicle radiators. The primary object is to provide means whereby the surreptitious removal of ornamental caps is prevented. A further object is to construct a device of this character in such way as to adapt it to use on a radiator cap of any of the well-known types and to permit of its insertion through the radiator filling opening.

SCOOP BOARD.—W. J. COMBS, Box 24, Otterbein, Ind. The object of the invention is to provide a scoop board especially adapted for use on wagons for hauling coal or granular material, wherein the board provides an end gate under normal conditions, but may be lowered into inclined or approximately horizontal position to serve as a scoop board, and wherein the pressure upon the board may be first relieved before the board is opened to permit its use as a scoop.

WHEEL.—L. H. KRICKEL, 300 S. Grand St., Monroe, La. The invention relates more particularly to a demountable rim. An object is to provide a device of this character in which the rim parts are so formed and associated with each other that while they are positively retained assembled and in position for immediate mounting on the wheel, they are adapted to be easily disassembled and reassembled to remove or replace the tire when necessary.

AUTOMOBILE LOCK.—W. H. AUSTIN, c/o Morgan Austin Co., Greenville, S. C. This invention has for its object to provide mechanism of the character specified for locking the spare tire of a motor vehicle in a casing, adapted to be secured to the body of the vehicle, in such manner that it cannot be removed by an unauthorized person.

RADIATOR FILLER CAP.—C. F. TAYLOR, c/o Superior Bearing Bronze Co., 719 1st Ave., New York, N. Y. The invention relates to safety appliances for caps and has particular reference to filler caps for automobile radiators. Among the objects is to provide a permanent connection between the cap and radiator structure to prevent possible loss of the cap, and to provide the connection for the quickest and easiest means for opening the neck for introducing water to the radiator.

DEMOUNTABLE RIM.—W. S. WATSON, 508 Sloan Bldg., Cleveland, Ohio. An object of this invention is to provide a demountable rim without necessitating the use of wedges that are liable to distort the wheel and thereby cause excessive wear on the tire. A further object is to provide a rim having adjustable fastening means, so that the pressure may be equally distributed around the wheel. The device is especially adapted for use with inner rims of the flat band type.

TRACTOR FORWARD AND REVERSE GEARING.—G. H. SCANLAN, c/o Consolidated Gas and Gasoline Engine Co., 202 Fulton St., New York, N. Y. Among the objects of the invention is to provide a tractor in which a simple effective reversing mechanism is provided which will be extremely small and simple in construction so as not to increase appreciably the size of the structure. Another object is to provide a structure in which the wheels may be adjusted so as to raise and lower the casing to comply with different requirements.

NON-SLIP ATTACHMENT.—S. C. SHERRY, Park Ave., West Englewood, N. J. This invention relates to attachments for the drive wheels of trucks or other automobiles which will prevent slipping of the wheels in snow and mud, and hence prevent stalling of the car. A further object is to provide a device which can me readily attached, and which will provide a laterally and radially projecting web to take hold of the snow.
and mud, and hence prevent a device which can be readily attached, and which will provide a laterally and radially projecting web to take hold of the snow.

GEAR LOCK.—J. O. TYLER, Box 376, Winchester, Ky. An object of the invention is to provide means whereby drivers, especially beginners, may be better able to hold down the clutch when they go to shift the gears, and whereby the gears are locked in position and are not able to be moved by the gear shift rod until the clutch is depressed.

VEHICLE BODY.—G. P. CONNEALY, Decatur, Neb. The invention relates to vehicle bodies which can be quickly adjusted either to form a solid body for carrying grain or extended to form a large receptacle in the form of a slatted rack for shipping hogs, sheep or other animals. A further object is to provide a vehicle which in either form will be strong and durable in construction.

Stopping the Chimney Thief

(*Continued from page 115*)

something that can be approached but not attained in practice. If carbon were burnt with twice as much air as necessary, only half of the 21 per cent of oxygen would be converted into CO_2 and the CO_2 measurement would be 10½ per cent. Three times as much air as necessary would mean that only one-third of the 21 per cent of exygen was converted into CO_2, that is 7 per cent.

The percentage of Co_2 therefore shows how much air was used per pound of fuel. Modern power plants use very accurate instruments which continuously and automatically determine the percentage of CO_2 in the chimney gases. These instruments serve a double purpose. First they enable the fireman to maintain maximum combustion economy at all times and secondly they register a permanent autographic record in chart form which enables the manager of the plant or engineer in charge to ascertain whether fuel was wasted or conserved during any period of time. In all power plant work the modern tendency is toward permanent recording of all important operations. In no case is it more profitable to do this than in connection with CO_2 recorders which are making actual fuel savings of from 10 to over 30 per cent and more in the quantity of fuel burned.

When all power plant owners stop competing with the sun in trying to heat up the sky and the countryside and keep their heat within the limits of their own domains a very big forward step will have been made in eliminating our many fuel problems. A power plant never will be run efficiently until its operators learn to think in terms of ratio of air to fuel instead of in terms of fuel alone, or better still when they allow automatic instruments to do part of their thinking along these lines for them.

Open Roads All Winter

(*Continued from page 104*)

hedges which add to the highway's beauty are usually left and the drifts removed instead.

Where cuts drift full, or where the general contour of the country causes drifting, the erection of snow fences will prove helpful by clearing the air currents of snow before they pass over the road. These fences are erected on the windward side of the road 50 to 60 feet distant from the highway and may be either permanent or portable. On land which is used for agricultural purposes the portable fences have a wider adaptability in highway work, as they can be set up after the crops are harvested and removed before they are planted the next year. Snow fences may be either of the "board fence" or the picket variety. The best fence, however, is one made of light pickets held in place by strands of heavy wire. Such fences can be readily erected on driven posts and when not in use rolled up and stacked where they will be out of the way.

After all preventive measures have been employed much snow that lies as it falls and minor drifts which cannot be economically handled by the erection of fences must be removed. In some parts of the Northern States, even when preventable drifting has been eliminated, the snowfall is so heavy that the problem of keeping the highways clear is difficult.

Two methods of keeping roads open to traffic where the snow is heavy are in common use—compaction and removal. On roads where the traffic is light and is composed principally of horse-drawn vehicles and a few light automobiles, packing the road after each snowfall with a roller six or eight feet in diameter and from 10 to 12 feet long, will result in a passable road. The compaction method, however, is not satisfactory for roads where the traffic is heavy, or where many automobiles or heavy trucks must use the highway, as motor vehicles lose traction in snow and spin their drive wheels until they are stalled the same as in mud or heavy sand.

One great disadvantage of this system is that it facilitates the formation of ruts. Snow cuts away rapidly, and as there is a tendency for each vehicle to follow in the track of its predecessor, bad ruts are soon formed. These are often cut through to the underlying pavement which frequently is materially damaged thereby. This tendency of snow to form ruts is one of the best reasons for removing the snow from highways. Where snow ruts form, the damage done the highway is often much greater than the cost of removing the snow would have been.

On roads which must be kept clear and where the traffic is such that compacting the snow is not sufficient, removal is the only solution. This may be accomplished either by the use of plows or by shovels. Rotary plows sometimes are used, but have not been commonly adopted for the work in this country. The present practice is to push the snow off the highway with blades similar to those used in road grading. Indeed, road graders are frequently used for this work where the snowfall is light. The more common method, however, is to fasten a heavy blade to a heavy truck and to use the powerful driving force of the truck to push the snow off the highway. When the fall of snow is unusually heavy a second truck is attached to the one that carries the plow.

As soon as two or three inches of snow has fallen, work is started. To prevent drifting, it is better to move all the snow to the leeward side of the road, but it may be shoved off to both sides. The first clearings of the season should be made sufficiently wide to allow for storing the later snowfalls. It is best to clear at least ten feet more than the traveled way. This extra width, which is an inconvenience to make and adds to the cost of the removal of the first snowfalls, usually proves a time and money saver in the end.

An efficiently operated truck can handle about ten miles of highway in snow removal work. Preferably two assistants should accompany the driver, and the truck always should be in the best of condition. If a heavy blanket of snow is being removed, a half dozen men with shovels should accompany the truck. Under normal conditions, a well-handled truck should make one cut an hour. If the truck is kept in constant operation as long as the storm continues the final result is an open road.

Occasions will arise, however, when high winds and the failure to provide proper snow fences will cause drifts to fill in, in spite of all the trucks can do. When this occurs, the usual method is to put men in with shovels to clear away the drift. The width cleared by the shovelers should be sufficiently wide to give the trucks a chance to handle the later falls. Hand work is expensive and the temptation to clear a minimum width is strong, but if the cuts are not wide enough for the trucks to handle later snow removals, the snow must be removed by hand and this increases the expense.

In the past, Pennsylvania has been the leader in snow removal. This winter it is doing more than ever has been attempted in the State before. Seventy-five additional trucks, with snow plows and correlated mechanical facilities and snow removal organizations, have been added to its equipment.

The snow removal problem in Pennsylvania is difficult because of its many mountains and heavy snowfall. By removal of weeds, brush, and obstructions along the roadside in the fall, and by the liberal use of snow fences, the highway commissioners of that State, however, have found it possible to control drifting in such manner that heavy trucks can

keep the roads clear with a minimum of assistance in the way of hand work.

The Pennsylvania Highway Commission also makes use of the Weather Bureau of the United States Department of Agriculture in combating the snow. The Weather Bureau informs the Highway Department in advance of the approach of storms and this information is sent at once to the field engineers, who, with knowledge of the intensity of the coming storm and its probable duration, are more prepared to cope with it than they would be if it came unannounced. As getting on to the job in time and keeping on it until the storm is over are two of the most important factors in fighting a heavy snowfall, this advance information is of utmost importance in all States with a snow removal program. Another admirable detail in the Pennsylvania winter program is the system of daily reports to the public on the condition of the principal highways. These are given both directly and through the Weather Bureau's daily bulletins.

No point on any of the designated routes in Pennsylvania is blocked more than twenty-four hours before the headquarters organization takes a hand and men and equipment from other points are thrown in until there are enough to cope with the situation.

Stunts of the Stage

(*Continued from page 105*)

of the stage under this shield and emerge from the water inside the wings.

For completeness of detail in scenic effects there probably is no better example than is offered in "The Gold Diggers." In one scene of this play two rooms, complete in every detail, are built behind the regular stage set which the audience sees. When an actor comes on the stage, he enters one of these rooms, closes the door behind him and then enters the stage by a second door. Only at this time does the audience get the briefest glimpse into the room. Ordinarily a simple screen would be made to serve the purpose, but the producer of this play thought the elaborate setting necessary to secure the proper atmosphere. To heighten the effect (a ball is in progress) a twelve-piece orchestra is placed behind the scenes and it is heard only at intervals when the doors into the two extra rooms are opened.

For sheer cleverness of conception and execution the palm ought to be awarded to one of New York's motion picture palaces, which recently had its large orchestra directed from the screen by one of the animated characters of a famous comic cartoon. The "stunt" was devised by the snare drummer at the Rivoli Theater.

In the accompanying animated cartoon one of the characters leads an "animated" orchestra while the other sings. When the song is finished the roof has been blown off the theater, the audience has fled in wild panic and even the orchestra is gone. They determine to sing another song and for the purpose of accompaniment they borrow the theater's real orchestra. The cartoon character waves the leader to a seat when he takes up his baton and conducts the orchestra himself from the screen. The song is "The Curse of a Broken Heart," and the notes of the animated soloist are rendered in accompaniment by the drummer on an instrument especially designed for the purpose. It consists of an old bucket with the bottom knocked out. Over the end is stretched a skin and in the center is attached a resined rope. Weird sounds that follow the tune more or less closely are emitted when the rope is drawn through a resin-coated rag. An unearthly screeching-clattering sound produced by scraping an old piece of tin building cornice with another piece of tin interrupts the song. The comic characters engage in an argument with the drummer and the picture ends when the drummer jumps to the stage and apparently chases the two animated musicians from the screen.

On at least one former occasion an orchestra leader attempted to lead his orchestra from the screen, but this attempt was a failure. This time the leader was photographed in action and his image flashed on the screen. But it was found impossible to cut or edit the film because the elimination of a beat or a part of a beat threw the orchestra into confusion. It was found equally impossible to make a perfect film long enough to carry the orchestra through one piece. These difficulties were overcome by using an animated cartoon instead of a photograph.

Theatrical mechanics prove most useful, however, in the staging of a gigantic spectacle such as "Mecca," in which some 300 people take part. The whole production, in fact, must be a well-oiled mechanism. The performance is timed so that a certain piece of action takes place at a certain time and each player must be in a designated spot.

One scene in "Mecca" is shifted with the whole stage dark. The spot where each member of the company must stand during the shift is marked on the stage floor and should he or she move a foot to one side of this spot there would be danger of being run down by a piece of scenery.

A very large stage is required, of course, and in one scene a smaller stage, about the size of an ordinary theater stage, but mounted on wheels, is set in the wings and when the curtain goes down it is quickly pushed to the center and the story goes on with an interruption of only a few seconds for a complete change of scenery.

A new kind of stage fire is introduced in "Mecca," producing a most realistic effect. For several years theatrical producers who have made use of stage fire have paid royalties to a dancer who patented the familiar combination of paper streamers blown upright by an electric fan, with colored lights playing on them.

In "Mecca" the fire appears in two huge brasiers at opposite sides of the stage. The "flames" are of burnished copper and they are gradually brought into view by a mechanism actuated by a small electric motor. Smoke from incense and flashing colored lights make a most realistic reproduction of fire.

The producer has used lights as an artist uses his colors and the result is an artistic masterpiece, vivid and colorful and ever-changing.

The World War on Rats

(*Continued from page 105*)

Other gases have been used, such as some of the poison gases developed for the war; but as a general rule these have been found too dangerous to warrant their use.

In open spaces the rat warfare must perforce be more difficult and less efficacious. First of all, the rats must be deprived of their food as far as possible. Fine meshed screens must be placed about food supplies to keep out rats. All these measures are only temporary, for rats can cut their way through wire netting of appreciable thickness and even through cement, if given sufficient time —and proper inducement.

Refuse, garbage, old rags, old papers—all these things must be abolished if rat warfare is to be a success. The plugging of rat holes does not appear to be of much avail, because the rats make new holes about as rapidly as the old ones are rendered useless to them. Cats are of little use because they hesitate to attack rats. Dogs, while more courageous, are perhaps more spectacular than effective in the rat war. Far more efficacious are certain birds of prey, which fall upon young rats in their nests.

The best methods are either to capture the rats by means of traps, or to poison them. The traps have to be baited with care, for we are told that the rodents have

a remarkable sense of smell, and keep away from certain odors, such as tobacco and dead rats.

In various cities of the world a lively warfare against rats is under way. In Paris, 25 centimes per rat captured either dead or alive is being offered. In London a vigorous campaign is under way. New York has taken certain measures, and more thorough steps are being contemplated. New Orleans has constructed her warehouses to shut out rats, and the same can be said for San Francisco. Many other cities are now engaged in waging what appears to be a successful fight against one of the worst pests that confront the well-being of the human race.

The Big Dam on the Little San Diego

(*Continued from page 108*)

tubing carries the water from this equalizing reservoir to the coast lands. This tubing varies from 20 to 26 inches in diameter.

One of the views shows the downstream face of Hodges Dam. On the right is to be seen the system of buttresses. In the center of the picture, this system ends and is succeeded by the concrete portion of the spillway. Back of the whole structure is to be seen the valley of the San Dieguito River, now occupied in part by Lake Hodges. Another view shows a siphon resting on its trestlework. Still another view shows the upstream face of the great dam. The flutes of the main dam and also of the concrete spillway (on the right) are plainly to be seen here.

Hodges Dam and San Dieguito Dam are two of four distinct dams that have been built to one general type of design in a single California county, San Diego County. The former of these is perhaps the tallest multiple-arch dam in existence. One of the others is Murray Dam. It was built to increase the storage at that time provided by the old La Mesa Dam. In January, 1916, this old structure, a hydraulic-filled dam 65 feet high, was nearly carried away by the great flood then rampant. The Lower Otay Dam had failed with severe loss of life and property and the south dyke of the Sweetwater Dam had also gone out. The water had risen to within just about one foot of the crest of the old La Mesa Dam. Overtopping the crest meant the failure of the dam and great damage to property and loss of life. However, there was a sluice gate at the base of the dam which was closed. It was finally opened and the dam thereby saved. The new dam which supplements the old structure is Murray Dam. It has 30 arches of a span of 30 feet each. The height is 117 feet and the length 900 feet. Just as is the case with Hodges Dam the slope along the crown of the arches is 45 degrees. Both dams have their inclined flutes surmounted by short vertical ones. Murray Dam has in one bay at the extreme north end a self-charging siphon spillway. Its capacity is double the flood inflow of the great flood already mentioned. It is claimed that this device will regulate the level of the reservoir within 3 inches of the summit of the main coping. The spillway level is the same as that of the cope and the result of the automatic arrangements is a regulation of 100 per cent efficiency.

A multiple-arch dam may often be built very rapidly. Murray Dam was built in 7 months; San Dieguito Dam in less than 4 months. They are sometimes quite economical. Thus, the designer claims that the Murray Dam cost less than any other dam of its size in the world.

The remaining multiple-arch dam of San Diego County is Eagles Nest Dam. This is a little fellow built to create a fish pond and to impound water for a small lighting plant. The designer, Mr. Eastwood, calls the type exemplified here a Matilija or Butterfly Dam. The plan presents a butterfly appearance. There

are three arches. It is the first of its kind ever constructed. The central arch has a span of 70 feet and the side ones a span of 25 feet each. This dam closes an opening of 125 feet wide. There are only 184 cubic yards of concrete in the structure.

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(*Continued from page 109*)

tecture illustrating his story with photographs taken by himself.

What is the place of life in nature? How is this peculiar and special development which we describe as living to be derived from a cosmos which close observation shows to be subject everywhere to rigid determination by mechanical and mathematical laws? The question is asked by Dr. Ralph S. Little, who proceeds to discuss the problem in an able article.

Owing to the phenomenal demands for furs in recent years there has been a greater temptation than ever to substitute inferior furs for the more valuable ones by clipping, dyeing or pulling them, thus the appearance of the furs are so altered that it is difficult for anyone but an expert to distinguish the genuine from the imitations. An article by Dr. Leon Augustus Hausman deals with this subject and shows how the microscope enables us to distinguish the various furs.

"Indian Uses of Kelp" is the title of an interesting article by J. C. Leachman, in which he tells of various articles made by North American Indians out of different kinds of sea weed. These include fishing lines, bottles, and even toys, sections of stem being used to make the wheels of toy wagons. Sea weeds were also used in ceremonials and as amulets. Unfortunately, owing to the perishable nature of the materials, many examples of the use of kelp have been lost, but enough have been preserved to illustrate the value of marine vegetation to these primitive peoples.

With the all-seeing eye of the Roentgen ray experts are now examining old paintings to determine whether they are genuine. It has been found that the pigments used in previous centuries are much more opaque to X-rays than are modern paints made of aniline and vegetable dyes. The antiquity of paintings can therefore be determined by noting their opacity to the X-rays. The process is described in the February Monthly and is illustrated with some very interesting photographs and radiographs.

The February issue contains the usual departments of notes on various branches of technology and scientific research with the exception of the department conducted by the National Research Council, which is omitted this month, but will appear in the March issue.

The Heavens in February, 1921

(*Continued from page 112*)

Capella is high in the northwest, with Perseus below, and Andromeda setting. Cassiopeia, Cepheus and Draco are low on the northern horizon. The Little Bear is above the last two, and the Great Bear much higher, in the northeast.

Arcturus has just risen, north of east, and Spica is rising farther to the southward. Leo is well up in the east, and Hydra stretches from the southeastern horizon almost up to Procyon. A number of the bright stars belonging to the constellation Argo may be seen low on the southern horizon, but they are not conspicuous, as they are in southern latitudes; and the brilliant region of the Milky Way (which surrounds them is hardly visible to us at all.

The Planets

Mercury is an evening star throughout February. He reaches his greatest elongation or apparent distance east of the sun upon the 15th. At this time he is almost exactly in perihelion and his apparent distance from the sun is therefore unusually small, 18° 8′; but to compensate for this he is more than 7° farther north than the sun, and is therefore easily visible, setting at 7 P. M. He is brighter than any of the stars except Sirius, and should be conspicuous in the twilight. By the end of the month he gets very near the sun, and is lost to sight.

Venus is likewise an evening star, and she also reaches her greatest elongation during the month—on the 10th—at a distance of 46° 46′. Being farther north than Mercury, as well as farther from the sun, she remains visible until 9:20 P. M. Telescopically she looks exactly like a half-moon, though of only one-eightieth the apparent size.

Mars, too, is in the evening sky, between Mercury and Venus, but only half as far from the latter as from the former, and remains in sight until after 8 P. M. He is about 200 million miles from the earth, and is correspondingly faint.

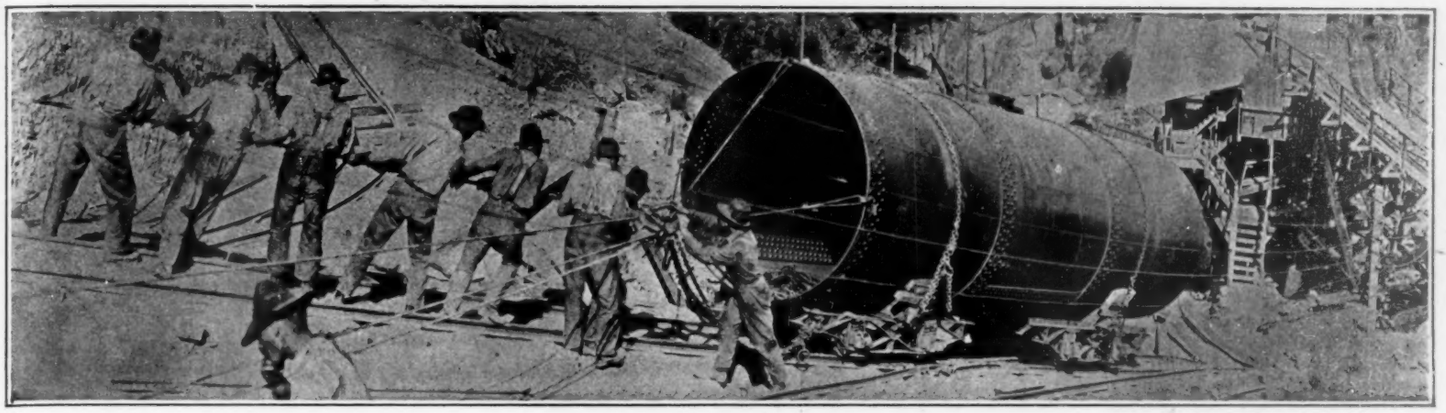
Jupiter is in the eastern part of Leo, and rises a little after 7 P. M. in the middle of the month, so that he is well placed for observation before midnight. Saturn is on the western edge of Virgo and about seven degrees east of Jupiter, rising approximately half an hour later. He is a telescopic object of extreme interest, for his rings are turned almost edgewise toward the earth. During most of the month their plane passes between the earth and the sun, and only the dark side is visible, so that with all but the greatest telescopes the planet appears merely as a disk, while with very powerful instruments the rings may be faintly seen illuminated by the light reflected from the planet, together with that which filters through from the sunlit side between the fine particles of which the rings are composed. On the 22nd the rings are turned exactly edgewise toward the earth, and (as previous observations at this phase have shown) they will be wholly invisible in even the greatest instruments. Then for about seven weeks we will see the sunlit side of the rings, very nearly edgewise, as a thin spike of light projecting from each side of the planet.

Uranus is in Aquarius, still an evening star, but too low to be observed. On the 24th he passes behind the sun and becomes a morning star. Neptune is in Cancer and comes to opposition on the 1st. At that time he is in 8h. 5m. 26s. R A and 17° 8′ north declination. He moves slowly westward, and on the 27th is in 8h. 56m. 39s., 17° 20′ north. Observers with equatorially mounted telescopes may find him along the line thus indicated; but a fairly large aperture will be required to show the planet's disk.

The moon is new at 5:37 P. M. on the 7th, in her first quarter at 1:53 P. M. on the 15th, and full at 11:32 A. M. on the 22nd. As this calendar month is shorter than the lunation, the moon does not pass through her last quarter in February at all. She is nearest the earth on the 20th, and remotest on the 5th. While making the circuit of the sky she passes close to Uranus and Mercury on the 9th, Mars early on the morning of the 11th and Venus on the same evening, Neptune on the 20th, and Jupiter and Saturn on the 23rd. The conjunction with Venus is close, and an occultation is visible in Asia; but we are unfortunately on the wrong side of the earth and will see nothing of this.

Skjellerup's Comet

An orbit of this comet has been computed at the University of California from observations covering an interval of nearly three weeks, and should be very near the truth. According to this the comet passed perihelion on December 11, at a distance of one hundred and thirty million miles from the sun. Its orbit is inclined 22° to the ecliptic, and it passed through the ascending node about two weeks after the perihelion. It is now slowly receding from the sun and more rapidly from the earth and growing steadily fainter, and there is no chance that it will ever become conspicuous.



A Question of Pulling Together

LOOKING backward about ten years you can see the man of science just beginning to emerge from the isolation of his lone laboratory to take up his experiments in practical research — to blaze the trail of scientific participation in industrial production. His microscope and sliderule were turned at that time to formulas, theories and solutions for the giant problems of the manufacturer.

Today the country's vast workshops and factories, its mines and forests form a joint foundation whereon science and industry join hands—*pulling together* in mutual co-operation for greater improvements in the life of the nation.

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Federal transportation has become a permanent, established factor in the nation's business. At the factory—on the farm—from the busy city's traffic to the remotest lumber camp—wherever highways traverse the earth—Federal has become a symbol of economical, efficient transportation.

Back of this great transportation service, and making possible its achievements, is the Federal organization—great factories equipped to produce, complete, this transportation unit of eleven years' undisputed leadership and service—resources that are second to none in the automotive field—and a globe-encircling distributing and servicing organization that serves Federals wherever they may operate.

This gift of organization that pervades the Federal Motor Truck Company is expressed to you in the reliability and serviceability of the Federals you operate.

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